

Change and Stability in Self-Reported Leisure-time Physical Activity Across Four Decades

Heterogeneity, domains and determinants

Frida Kathrine Sofie Mathisen

Thesis for the degree of Philosophiae Doctor (PhD)
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Scientific environment

This PhD project has been affiliated with the Social Influence Processes on Adolescent Health (SIPA) research group at the Department of Health Promotion and Development (HEMIL), Faculty of Psychology, University of Bergen. In addition, I have been a member of the focus group for physical activity in the Health Behaviour in School-aged Children (HBSC), a WHO cross-national study.

The doctoral education was conducted at the Graduate School of Human Interaction and Growth (GHIG) at the Faculty of Psychology, University of Bergen.

The data materials used in the project are from the HBSC study (under principal investigators Professor Oddrun Samdal (Norway) and Sami Kokko (Finland)) and the Norwegian Longitudinal Health Behaviour study (led by Professor Bente Wold).

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Abstract in English

Physical activity contributes to positive mental and physical health outcomes, but secular societal changes have raised concerns about increased sedentary behaviour. Insufficient physical activity levels among adolescents and adults make promoting physical activity a public health priority, and increased knowledge about developmental patterns of physical activity over time is central to reaching global policy goals to reduce inactivity.

To understand physical activity development over time, it is relevant to acknowledge the widely complex and multidimensional nature of this health behaviour. Ecological frameworks are widely used in this field, and the Youth Physical Activity Promotion model adopts a socio-ecological framework by recognising the contribution of various personal, social, and environmental influences on youth physical activity. Further, it unites constructs from different theoretical frameworks to highlight the possible processes promoting physical activity. Determinants may vary depending on contextual factors, e.g. domains, or situational factors, such as the type or intensity of the studied activity behaviour. Unfolding this complexity when studying physical activity can be challenging, and there is a need for incorporating theoretical perspectives to guide the understanding of the processes involved in the change or stability of behaviour over time. Therefore, the thesis explored the stability and change in leisure-time vigorous physical activity from a life-course perspective and related to secular changes. The Youth Physical Activity Promotion model was used as a conceptual framework to explore different enabling, reinforcing, predisposing and personal demographic factors that can explain differences in developmental patterns in leisure-time vigorous physical activity.

The thesis consists of three papers. Papers 1 and 2 were based on data from 1103 respondents who participated in ten waves over 27 years in the Norwegian Longitudinal Health Behaviour study. The baseline measure was conducted in 1990 when the participants were 13 years old, and the last survey was conducted in 2017 at age 40 years. In paper 2, self-reported information from parents was included for 614

respondents. Paper 3 was based on Norwegian and Finnish data from cross-sectional nationally representative surveys in 1985 and 2014 in the Health Behaviour in School-aged Children (HBSC) study. The sample used in this paper included a total of 16 355 respondents aged 11-, 13- and 15- years old. Data analysis included latent class growth analysis with a distal outcome model using the BCH approach (paper 1), multivariate multinomial logistic regression (paper 2) and linear mixed model (paper III).

Four distinct leisure-time vigorous physical activity trajectories were identified over the 27 years: active (9%), increasingly active (12%), decreasingly active (25%) and low active (54%). Overall, there was a declining tendency in level of activity from 13 to 40 years, except for the increasingly active trajectory. Sub-group differences between the patterns of development were also found in relation to several activity domains (participation in organised sports, diversity in leisure-time activities, outdoor recreation and peer physical activity) and to demographic (male), psychological (intentions for vigorous physical activity and enjoyment in sports) and social (mother's physical activity and father's encouragement) determinants of trajectory membership. Sub-group differences were also identified in the secular changes from 1985 to 2014 concerning leisure-time vigorous physical activity and participation in organised sports in Norway, showing an increase in participation in organised sports among 11-year-olds, a decrease in participation among 15-year-olds and an increase in the mean level of leisure-time vigorous physical activity only among those who reported being members of organised sports.

The identified heterogenic development of leisure-time vigorous physical activity at both individual- and group-level calls for targeted health promotion interventions among different subgroups and stages of life. Few previous studies have identified trajectories of leisure-time physical activity from adolescence to adulthood and what characterises these trajectories and their determinants. This thesis contributes to the field of trajectory studies by applying a wide range of previously identified determinants of adolescent physical activity behaviour. It supports the theory of planned behaviour regarding behavioural intentions being the most proximal

determinant of human behaviour as it was associated with following a persistently high activity level from adolescence to adulthood. The findings suggest that participation in organised sports clubs is related to the level of leisure-time vigorous physical activity. However, there does not seem to be a sustainable carry-over effect of earlier participation on leisure-time vigorous physical activity later in life. Hence, there needs to be more awareness of dropout and retention in organised sports clubs to promote lifelong engagement and higher physical activity levels.

Abstract in Norwegian

Fysisk aktivitet bidrar til positive mentale og fysiske helseutfall, men samfunnsendringer har ført til bekymring for økt stillesittende atferd. Den reduserte fysiske aktiviteten er en prioritet for folkehelsen og det er viktig å øke kunnskapen om utviklingsmønstre for fysisk aktivitet for å kunne nå målene om å redusere inaktivitet.

For å forstå utviklingen av fysisk aktivitet over tid, er det viktig å erkjenne kompleksiteten til helseatferden. Youth Physical Activity Promotion-modellen benytter et sosioøkologisk rammeverk ved å inkludere ulike personlige, sosiale og miljømessige påvirkninger på ungdoms fysiske aktivitet. Videre forener den konsepter fra ulike teoretiske rammeverk for å fremheve mulige prosesser som fremmer fysisk aktivitet. Determinanter kan variere avhengig av kontekstuelle faktorer, for eksempel domener, type eller intensitet av den studerte aktivitetsatferden. Kompleksiteten ved fysisk aktivitet gjør at det kan være utfordrende å studere. Derfor er det viktig å bruke teoretiske perspektiver som inkluderer et bredt perspektiv for å forstå prosessene involvert i endring eller stabilitet av atferd over tid. Avhandlingen utforsker stabiliteten og endringen i anstrengende fysisk aktivitet på fritiden ut fra et livsløpsperspektiv og i sammenheng med samfunnsendringer over tid. Youth Physical Activity Promotion-modellen ble brukt som et konseptuelt rammeverk for å utforske ulike muliggjørende, forsterkende, predisponerende og demografiske faktorer som kan forklare forskjeller i utviklingsmønstre.

Avhandlingen består av tre artikler. Artikkel 1 og 2 baserte seg på data fra 1103 respondenter som deltok i ti datainnsamlinger over 27 år i «Voksen i år 2000»-studien. Første datainnsamling ble gjennomført i 1990 da deltakerne var 13 år gamle, og den siste undersøkelsen ble gjennomført i 2017 da de var 40 år gamle. I artikkel 2 ble selvrapportert informasjon fra foreldre inkludert for 614 deltakere. Artikkel 3 baserte seg på norske og finske data fra den nasjonalt representative tverrsnittsundersøkelsen Health Behaviour in School-aged Children (HBSC) i 1985

og 2014. Utvalget som ble brukt i denne artikkelen omfattet totalt 16 355 deltakere i alderen 11, 13 og 15 år. Dataanalysen inkluderte latente vekstklasseanalyser med en distal utfallsmodell ved hjelp av BCH-metoden (artikkel 1), multivariat multinominell logistisk regresjon (artikkel 2) og lineær blandet modell (artikkel 3).

Fire forskjellige utviklingsbaner for fritidsrelatert kraftig fysisk aktivitet ble identifisert over 27 år: aktiv (9%), økende aktiv (12%), avtagende aktiv (25%) og lav aktiv (54%). Generelt var det en nedadgående tendens i aktivitetsnivået fra 13 til 40 år, bortsett fra for den økende aktivitetsbanen. Det ble også funnet forskjeller mellom utviklingsbanene i forhold til flere aktivitetsdomener (deltakelse i organiserte idretter, variasjon i fritidsaktiviteter, friluftsliv og fysisk aktivitet blant jevnaldrende) og i forhold til demografiske (menn), psykologiske (intensjoner og glede i idrett) og sosiale (mors fysiske aktivitet og fars oppmuntring) determinanter for utviklingsbanetilhørighet. Det ble identifisert undergruppeskjeller i sekulære endringer fra 1985 til 2014 når det gjelder anstrengende fysisk aktivitet på fritiden og deltakelse i organiserte idretter i Norge. Det viste seg at deltakelse i organiserte idrett økte blant 11-åringene, mens den gikk ned blant 15-åringene. Videre var det en økning i gjennomsnittlig nivå av anstrengende fysisk aktivitet på fritiden bare blant de som rapporterte at de var medlemmer av organiserte idrett.

Den identifiserte heterogene utviklingen av anstrengende fysisk aktivitet på fritiden på både individuelt og gruppenivå krever målrettede helsefremmende tiltak blant ulike subgrupper og i ulike livsfaser. Få tidligere studier har identifisert utviklingsbaner for fysisk aktivitet med høy intensitet på fritiden fra ungdomstiden til voksenlivet og hva som kjennetegner disse banene og deres påvirkningsfaktorer. Denne avhandlingen bidrar til feltet for studier av utviklingsbaner ved å anvende et bredt spekter av tidligere identifiserte påvirkningsfaktorer for fysisk aktivitetsatferd blant ungdommer. Den støtter teorien om planlagt atferd med hensyn til atferdsintensjoner som den mest umiddelbare påvirkningsfaktoren for menneskelig atferd, da det ble funnet å henge sammen med å opprettholde et konsekvent høyt aktivitetsnivå fra ungdomstiden til voksenlivet. Funnene antyder at deltakelse i organiserte idrett er relatert til nivået av anstrengende fysisk aktivitet. Imidlertid ser

det ikke ut til å være en varig effekt av tidligere deltakelse på anstrengende fysisk aktivitet senere i livet. Derfor er det behov for økt bevissthet om frafall og opprettholdelse i organiserte idrett for å fremme livslang deltagelse og høyere nivåer av fysisk aktivitet.

List of Publications

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1. Introduction

It is now well-established that physical activity (PA) contributes to positive outcomes on mental and physical health (Chaput et al., 2020; Sluijs et al., 2021). Secular changes in society, such as increased car ownership and the use of electronic media and technology, have raised concerns about the increase in sedentary behaviour as the daily demand for physical activity decreases (Pate et al., 2016). The global recommendations for aerobic exercise for adults are at least 150-300 minutes of moderate-to-vigorous intensity, or at least 75-150 minutes of vigorous-intensity or a combination of these throughout the week. Among youth, an average of 60 minutes per day of moderate-to-vigorous intensity across the week is expected to provide health benefits (Bull et al., 2020). Recent global estimates show that 27.5% of adults (Guthold et al., 2018) and 81% of adolescents (Guthold et al., 2020) do not meet these recommendations. Hence, insufficient PA levels among adolescents and adults make promoting PA a public health priority. Increased knowledge about the developmental patterns of PA over time and through life and how these patterns are influenced by societal changes or known determinants is central to reaching global policy goals to reduce inactivity (WHO, 2018).

Previous research on the correlates and determinants of PA calls for a multidimensional approach to understanding PA development. The predominant definition of physical activity for more than 30 years has been that of Caspersen et al. (1985), defining PA as «any bodily movement produced by skeletal muscles that results in energy expenditure» (p. 126). The definition has been widely accepted in the research community and applied in health policies worldwide (Hansen et al., 2015; WHO, 2018). This definition takes a biomedical stand and does not embrace the complex and ecological nature of PA behaviour. By defining PA otherwise, one can take in PA's inherent cognitive, social, setting-based, and political nature. Expanding the definition opens up new reflections and a broader understanding of PA in research. Recently, Piggan (2020) has defined PA as follows:

«Physical activity involves people moving, acting and performing within culturally specific spaces and contexts, and influenced by a unique array of interests, emotions, ideas, instructions and relationships».

This new definition moves away from the strong biomedical focus to the widely complex and health-promotive possibilities of PA, contributing to and being affected by much more than skeletal muscle movement and energy expenditure. It also allows for a more extensive consideration of what promotes or hinders participation in PA (social, cultural, political and contextual factors).

In promoting youth physical activity, one implicit goal is to increase the probability that they will adopt an active lifestyle and maintain a regular habit of PA as they grow older. Moreover, while some maintain their interest and engagement in physical activity, most youths decrease their level of involvement (Sluijs et al., 2021). Based on previous research on secular trends and life course development (Corder et al., 2019), there is a need for more knowledge related to the stability and change of physical activity to inform health promotion to increase activity behaviour.

Adolescence is considered formative years, as individuals gain physical, cognitive, emotional, social, and economic resources to build the foundation for later life health and well-being (Patton et al., 2016). As many factors that influence adult health have their genesis in childhood, a coinciding assumption has become that the health-related benefits of regular PA are established at a young age, assuming that individuals settle into relatively stable and predictable patterns of PA and its correlates in their childhood (Seefeldt et al., 2002).

1.1 Domains for physical activity

In research on physical activity, it is helpful to define in which contexts the activity is performed, as is emphasised in Piggin's definition of physical activity ("*people moving, acting and performing within culturally specific spaces and contexts*"). Within the present research field, there are some discrepancies related to what is defined as the domains of PA. Some define domains as related to the areas of life in

which activities are done, meaning at home, at work, in transport, and in leisure time (Bauman et al., 2012; Cleland et al., 2012; Eime et al., 2016), and further define *modes*, *settings* and *types* of PA within those areas. Modes then refer to ways of participation within this domain, e.g., team sports, individual sports, and non-organised activities. Others use domains to describe different arenas for PA, such as organised PA, non-organised PA or active transport (Kemp et al., 2019). Regardless of whether the term domains or modes are used, it is apparent that the awareness of the contextual setting of PA is essential for building knowledge that is specific and applicable in developing health promotion interventions. In this thesis, limited to the context of leisure-time PA, domains are used to describe arenas that might contribute to leisure-time vigorous physical activity (LVPA) in adolescence and adulthood. Different domains are not mutually exclusive but can overlap in many instances. The domains for PA investigated in this thesis include; organised sports clubs, diversity in leisure-time activities, peer PA and outdoor recreation.

Unlike in other Western countries, like the US and UK, organised sports in the Nordic countries are strongly related to time after school, with little or no collaboration between school and sports clubs (Eiðsdóttir et al., 2008). Organised sports are an essential part of leisure time among youth, and in a modern lifestyle, time after school has significant potential for vigorous physical activity (VPA) (Kokko et al., 2018; K. Mäkelä et al., 2016; Taliaferro et al., 2010). Participation in organised sports also provides structures for social interaction and the development of skills, which are thought to contribute to the development of lifelong PA by establishing habits, abilities, and continued participation (Telama, 2009).

In order to understand the changes in leisure-time PA in adolescence, several other studies have looked into the possible importance of participating in a wide range of different activities (Jose et al., 2011; Kjønnsen et al., 2008; S. Mäkelä et al., 2017) and suggest that engagement in several leisure-time activities during adolescence may refine motor skills and promote the maintenance of higher levels of leisure-time physical activity later in life. Earlier experiences with activities may contribute to both maintenance or re-engagement in PA, also if the activity differs from the earlier

experience based on the attained abilities and motor competence (Engström, 2008; Telama, 2009).

When considering activity domains related to the level of LVPA, interaction with best friends can be a meaningful context to consider. Best friends are essential peers and agents for behaviour and development in the adolescent years. In childhood and adolescence, PA is usually performed together with peers, and peers can influence the individual's level of PA through behavioural modelling, peer pressure, group norms and co-participation (Sawka et al., 2013).

In Norway, the concept of nature-related outdoor recreation, *friluftsliv*, which is considered a core social and cultural value in Norway (Gurholt & Broch, 2019) can also act as an important domain for PA, and many spend their weekends and holidays outdoors while hiking, fishing or tracking in the mountains. As large areas outdoors are accessible to all and do not require a membership or special equipment, outdoor recreation may contribute to lifelong LVPA more broadly than organised sports or activities in fitness centres. Different forms of outdoor recreation may contribute to the level of PA throughout the entire life. Outdoor recreation is highly flexible, as the same activity can be done with a wide variety of intensities and is thus maybe more adaptable than other activities.

One criticism, when the aim is to explore activity behaviour throughout the life course, is that the activity domains or activities practised in youth are inherently different from those practised in adulthood. While tracking shows whether they maintain their PA ranking over time, it does not necessarily address the issue of whether they maintain their PA level. However, early experiences might prepare, mould, or modify health behaviours later in life and help in the understanding of stability and change over time.

1.2 Determinants of physical activity

In the search for what might cause the development of an active lifestyle, one must move away from the search for traditional causal pathways and adhere to the

possibility of multiple causal factors, reciprocal determinism and the possibility that exposure to a factor does not always lead to a behavioural outcome (Bauman et al., 2002). Determinants are defined as causal factors, which entails that variations in these factors should be followed systematically by variations in behaviour. In the field of behavioural science, most studies have used the term *determinant* concerning findings that demonstrate associations or predictive relationships, which should be considered correlates and not cause-and-effect relationships. Many variables in PA research are likely to be correlates rather than true determinants (Bauman et al., 2012). While correlates point to factors related to the behaviour in question, determinants indicate some form of causal relationship and are best explored using longitudinal designs (Bauman et al., 2002).

Determinants of PA can be categorised into biological, psychological, and sociocultural factors, in addition to factors associated with the physical environment and personal behavioural attributes and skills (Bauman et al., 2012; Sallis et al., 2000; Sterdt et al., 2014). Identifying the numerous factors that might determine PA across the life course is needed, and adolescent determinants are of interest as several possible determinants have their genesis in youth (Sterdt et al., 2014).

2. Theoretical framework

In line with a broader definition of PA and acknowledgement of the widely complex and multidimensional nature of this health behaviour, it is applicable to consider a broad framework to understand PA and how multilevel determinants contribute. These multilevel determinants emerge from the individual, social, environmental and policy levels, and knowledge developed when considering all types of influence can inform the advancement of multileveled interventions set out for success (Biddle, 2023). A key conceptual principle for frameworks for understanding PA is that the environment-behaviour relationship is transactional and characterised by recurring cycles of reciprocal influence between the individual and their surroundings. This emphasises the importance of acknowledging that the influence of different determinants may vary depending on contextual factors, such as domains, or situational factors, such as the type or intensity of the activity behaviour being studied. PA behaviour is influenced by a constellation of determinants and their interaction. Unfolding this complexity when studying physical activity can be challenging, and there is a need to incorporate theoretical perspectives to guide the understanding of the processes involved in the change or stability of behaviour over time.

2.1 The Youth Physical Activity Promotion Model

Welk (1999) has developed a simple, usable, and heuristic conceptual framework for facilitating the promotion of PA among youth, the Youth Physical Activity Promotion (YPAP) model. This model is based on the health promotion planning model by Green and Kreuter, the *Precede-Proceed model*, focusing on taking a given population's characteristics and needs into consideration before establishing a health promotion program (Green & Kreuter, 1991). The YPAP model serves as a starting point for connecting some of the known determinants and correlates of PA behaviour (Welk, 1999). As the model is developed for youth, it does not reflect upon the possible challenges in health promotion across different stages of life. However, the core focus of this thesis, namely the importance of determinants and domains relevant

in adolescence and their possible effect on life-course PA in developmental trajectories over time, is highly relevant to this framework. Hence, the YPAP model will, in addition, be implemented to conceptualise the influence of time on both individual and societal development.

The YPAP model adopts a socio-ecological framework by recognising the contribution of various personal, social, and environmental influences on youth physical activity. The model also unites constructs from competing theoretical frameworks to better highlight the possible processes that help promote PA and will therefore be used to highlight processes involved in the development of PA over time.

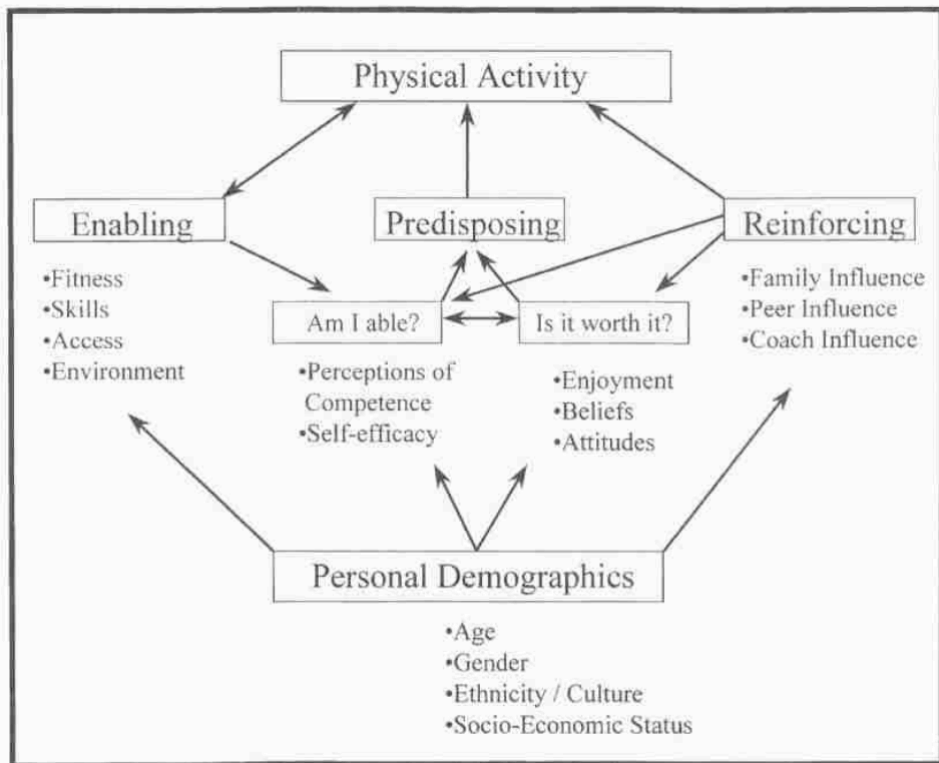


Figure 1 A conceptual diagram of the Youth Physical Activity Promotion Model. Reprinted from Welk (1999) QUEST ©1999, reprinted by permission of Informa UK Limited, trading as Taylor & Tylor & Francis Group, <http://www.tandfonline.com>

The model focuses on four main aspects and the interplay between them: the predisposing, the reinforcing, the enabling, and the demographic factors. The first three factors may directly encourage or discourage youth's PA, whereas the enabling and reinforcing factors may also influence PA indirectly through the predisposing factor. At the base of the model is the demographic factors that directly may influence how the individual responds to the other three factors (see Figure 1).

Presenting the YPAP model, three prominent and well-established theories within health behaviour science will also be presented, namely the theory of planned behaviour (TPB), social cognitive theory (SCT) and self-determination theory (SDT). These theories are well suited to highlight different aspects of the model and aid in the knowledge development related to change and stability of physical activity over time. Integrating the three theories is recommended to understand better the mechanisms underlying activity behaviour (Cortis et al., 2017).

The *predisposing factor* incorporates elements from various interpersonal theories without being strictly tied to one approach. Two fundamental questions are raised; «Am I able?» representing the social learning theories, and «Is it worth it?» related to motivational theories. Social learning theories are known for suggesting that activity behaviours are influenced by interactions between a person's attitudes, social norms and surrounding influences. Motivational theories, on the other hand, focus on emotions as drivers for a person's decision to participate or maintain interest in voluntary behaviours such as PA (Welk, 1999).

The first component («Is it worth it?») includes cognitive and affective variables, such as attitudes towards physical activity or enjoyment of sports. In the other component («Am I able?»), variables related to perceived competence or self-efficacy are included. The TPB (Ajzen, 2002) is related to this component. According to TPB, the likelihood that an individual will engage in physical activity is related to the individual's intentions to engage, and three types of considerations guide those intentions; behavioural beliefs (beliefs about the probable consequences of the practised behaviour), normative beliefs (beliefs about the normative expectations of

other people), and control beliefs (beliefs about the presence of factors that may enable or obstruct the performance of the behaviour). While behavioural beliefs are related to favourable or unfavourable attitudes towards the specific behaviour, normative beliefs are related to subjective norms or expectations from other people, and control beliefs are related to what extent the individual perceives themselves to have behavioural control. These beliefs influence the individual's intentions to perform the behaviour (Ajzen, 2002). It seems relevant to expect that the beliefs influencing behavioural intentions are not only related to cognitive but affective aspects as well. TPB has been criticised for not considering the emotional aspect of forming beliefs. Previous research found that the standard TPB variables explained 48% of the variance in intentions to increase PA, but that by adding affective attitudes, an additional 11% of the variance was explained (French et al., 2005). To fully understand the mechanisms underlying PA behaviour, it is recommended to carefully combine and integrate several theories and models (Cortis et al., 2017). In the YPAP model, the combination of cognitive and affective determinants of PA behaviour in the predisposing factors conceptualises this. There are strong connections between the two components (“am I able?” and “is it worth it?”), as it is likely that a person values what they are good at and pursues what they value. Also, Welk (1999) proposes that if a person answers «yes» to both questions, they likely have an athletic identity and might be predisposed to an active lifestyle.

According to the SDT, fostering competence, relatedness and autonomy is needed in order to facilitate optimal functioning, psychosocial development and well-being (Ryan & Deci, 2000). Athletic identity may be an important psychological determinant of life-long PA because identity affects the regulation of behaviour. Continued activity behaviour can incorporate activity as a defining element of one's self-identity, motivating continued activity (Reifsteck et al., 2016). Individuals establish their identities because identity supports their feeling of competence and the need for autonomy (Ryan & Deci, 2000), thus in line with the argument mentioned above by Welk (1999) regarding the presence of an athletic identity when answering «yes» to both questions. Previous research has found that adherence to long-term physical activity is strengthened by the fulfilment of the three basic needs in SDT and

occurs when the value of participation becomes internalised as a component of self-identity (Springer et al., 2013). There is a complementary nature of SDT and identity theory in that both theories focus on the self, identity, motivation and self-regulation of behaviour (Reifsteck et al., 2016).

The *reinforcing factors* are those that reinforce or support PA behaviour. This includes social determinants such as parental encouragement, parental modelling and family support, and peer support and support from coaches. In the model, the reinforcing factors, directly and indirectly, influence physical activity. The direct influence is by facilitating participation in physical activity, such as parental instrumental support for participation, e.g. driving the youth to practise and games, or by directly encouraging them to be active. The indirect influence is through forces that shape the youth's predisposition to activity behaviour. This can happen through the «Is it worth it?» component, by which the parents influence the youth's PA as they adopt the same beliefs related to the importance of physical activity, but also through the «Am I able?» component, where parental encouragement has been found to predict increased vigorous physical activity indirectly through the enhanced perception of own competence (Biddle & Goudas, 1996). Young children rely on adults, especially parents, for information regarding their physical abilities. This makes parents or other significant adults, such as coaches and teachers, essential agents in a child's development and predisposition towards physical activity. Parents may also influence youths' PA involvement through their own PA behaviour, known as the principle of observational learning in SCT (Bandura, 1986). Role modelling affects the individual partly because exposure to active role models will make them more aware of opportunities to engage in PA, and increased attention can contribute to positive attitudes towards PA. This, in turn, can increase the individual's motivation to initiate and maintain PA.

Enabling factors are those factors that allow youth to be physically active. These could be variables from environmental and biological categories. Environmental attributes or activity domains, such as membership in organised sports clubs, access to outdoor areas, facilities for doing sports, parks, or programs, are often identified as

important determinants. However, while they might be necessary for activity behaviour, they are insufficient. Youth who have access may not use their resources, but without them present, there is no opportunity (Welk, 1999). Biological attributes are enabling factors, such as physical skills or fitness, which might predispose to physical activity. However, it is also likely that these biological enabling factors work indirectly on physical activity through the «am I able?» component related to their perceived competence.

Lastly, *demographic factors* are placed at the base of the YPAP model because they directly influence how a particular individual will take up various influences (Welk, 1999). In addition to demographic differences related to age, gender and socioeconomic status, there may also be cultural differences. Cultural differences can be related to secular changes or development, as the culture for physical activity might change over time. This may then affect the importance of different enabling factors (such as the popularity of sports and availability of arenas for doing sports), reinforcing factors (such as parental style), or predisposing factors (such as the collective value of sports in society).

2.2 Development of physical activity over time

As these demographic factors can influence all the other factors, it opens up for interpersonal differences. This can be related to societal changes, and it can be related to heterogenetic development in a population. The differences between developmental trajectories or different generations can be related to differences in the availability of enabling factors, the strength of the reinforcing factors, the importance of the predisposing factors and individual differences. How does development affect the factors in the YPAP model? Such reflections are not part of the initial model by Welk. While Welk developed the YPAP model mainly focusing on youth, it could also be useful to apply this model to the discussion of factors that might have contributed to the change and stability of LVPA over time.

To further understand the possible differences between individuals in developmental patterns of PA, four hypotheses have been proposed by Telama (2009). These are the habit formation hypothesis, the carry-over value hypothesis, the ability and readiness hypothesis and lastly, the self-selection hypothesis. The habit formation hypothesis suggests that those who are active are so, not only based on planned behaviour and intentions, but because it is automatic and performed with less awareness. To foster such habits, repetition is needed. Part of daily physical activity, such as daily walks or active transport, can be based on habits. It is also possible that low or in-activity is a stronger habit than high levels of PA. The carry-over value hypothesis proposes that adults will continue to engage in the activities they participated in at a younger age. However, the types of activities practised in adolescence are often different from activities practised in adulthood. A possible explanation for the tracking of and reason why experiences from adolescence can contribute to activity levels in adulthood is the ability and readiness hypothesis, which suggests that earlier experience and the basic skills connected to this experience contribute to the upholding of or re-entering into PA in adulthood, despite the differences in the type of activity. Lastly, the self-selection hypothesis recognises that hereditary disposition to fitness and motor performance in some people could also be a possible explanation for why some become more active than others because this predisposition makes them engage in PA more often in both adolescence and adulthood.

Either used individually or in a cumulative way, these hypotheses can aid in the explanation of possible paths of lifelong PA from adolescence to adulthood.

3. Development of leisure-time physical activity: A review of the literature

The review of the literature is focused on previous studies looking at either secular or longitudinal changes in leisure-time vigorous physical activity, development in activity domains and demographic, psychological and social determinants. Because of the limited number of studies looking at LVPA specifically, some other studies referring to total PA or MVPA are also included.

3.1 Secular changes among children and adolescents

Challenges related to summarising the secular changes in PA may be related to differences in the development within different domains of PA (V. M. Booth et al., 2015; Ekelund et al., 2011). In some domains of PA, such as active transport, the evidence for a decline in activity is more consistent. The variation in methodology and measures of PA between the included studies makes it difficult to present a coherent picture of the development of PA. Previous research on secular change in PA among children and adolescents has recently been summarised in the systematic review by Pinto et al. (2022). Of the 43 studies, 22 found a stable development, 16 found an increase, and 15 showed a decline in PA. Among those that reported on trends in VPA or leisure-time PA, most reported an increase or a stable development (Eiðsdóttir et al., 2008; J. C. Inchley et al., 2005; Mathisen et al., 2019; Palomäki et al., 2015; Samdal et al., 2007). Three of these studies are based on LVPA data from the HBSC, among those the third paper in this thesis. Included in the review were, however, also findings of a decrease among 11-year-olds and girls in a Canadian sample (Irving et al., 2003).

Previously, trends in LVPA in Finland and Norway based on HBSC data from 1986 to 2002 were presented in a cross-national study by Samdal et al. (2007). Among the six countries included, Finland was the only country showing a slight but consistent increase in the proportion reporting to engage in LVPA 4 times or more per week over this time period. In Norway, the development was stable over the 16 years. The

patterns were similar among boys and girls; however, age differences were not investigated. Changes from 2002 to 2014 based on the data from 35 countries within the HBSC study were presented in a report in 2017 (J. Inchley et al., 2017). There was a significant increase in most countries, except in relation to 13-year-old boys, where seven countries reported a decrease and six countries reported an increase. Both in Norway and Finland, there was an increase in the proportion who reported LVPA 4 times per week or more among all age groups and both genders. However, the increase was greater among 13 and 15-year-old girls than boys in both countries (J. Inchley et al., 2017).

Previous studies from the United States (Taliaferro et al., 2010), Denmark (Hebert et al., 2015), Portugal (Marques et al., 2016), Finland (K. Mäkelä et al., 2016), Iceland (Eiðsdóttir et al., 2008) and several European countries (Kokko et al., 2018) have found that being involved in organized sport increased time spent in MPA, VPA and/or MVPA.

Previous studies on secular changes in participation in organised sports clubs in four European countries have found an increase in organised sports participation among children and adolescents (Eiðsdóttir et al., 2008; Scheerder et al., 2005; Telama et al., 2009; Westerståhl et al., 2003).

As many as 93% of Norwegian youth report that they are or at some point have been members of an organised sports club (Bakken, 2017). While the proportion of adolescent participation over time has been stable since 1992, there are indications of change that might have increased dropout among older adolescents (Seippel et al., 2011). The decrease in participation may be related to an increased focus on specialisation and pressure both within organised sports and from school (Strandbu & Bakken, 2007).

According to a Swedish study (Westerståhl et al., 2003), adolescents participated less in traditional team sports activities from 1974 to 1995, while interest and participation in keep-fit activities outside traditional sports clubs increased. It was suggested that this could partly be explained by the increased body and health

awareness and the increase in new, informal sports activities offered in 1995 compared to 1974. New informal sports, such as keep-fit activities, jogging, strength training, cross fit, hiking, and skateboarding, have increased in popularity among adolescents (Gilchrist & Wheaton, 2011; Westerståhl et al., 2003). These activities do not require membership in an organised sports club. Thus, this may contribute to a change in the importance of participating in organised sports clubs for adolescents' VPA levels from the 1980s to the 2010s.

Few previous studies have looked at the development of LVPA in relation to participation in organised sports clubs among adolescents. However, one study from the United States found no indication of change between 1999 and 2007 in the interaction between sports participation and VPA by year (Taliaferro et al., 2010).

Evidence points to a consistent correlation between organised sports participation and VPA. However, there is limited evidence related to secular change and possible differences in LVPA in relation to participation and non-participation in organised sports, highlighting the need for more knowledge related to the development over time in LVPA across different subgroups and domains of PA.

3.2 Longitudinal changes from adolescence to adulthood

More needs to be known about the lifelong patterns of PA, and longitudinal data opens up for looking at such patterns over time and across various life events and transitions (Hirvensalo & Lintunen, 2011). Previously, there has been a focus on tracking studies when exploring the development of PA over the life course. Tracking refers to the tendency of individuals to maintain their rank or position within a group over time (Telama, 2009). However, there is inconclusive evidence that leisure-time PA in adolescence should carry over into adulthood, and previous studies have generally found low – to – moderate tracking (Telama, 2009; Hayes, 2019; Corder, 2019). A decline in the level of PA has been shown from adolescence to adulthood, with a slightly larger decline among boys (Corder, 2019), probably due to boys being more physically active than girls in adolescence. Previous tracking studies based on

data from the Norwegian Longitudinal Health Behaviour Study found a weak degree of tracking of leisure-time vigorous physical activity from 13 to 21 years (Pearson's r was 0.22 for boys and 0.18 for girls) and showing stability among those reporting to be least active (Anderssen et al., 2005).

While tracking identifies whether a person maintains their ranking in the population over time, it does not address whether they maintain their level of PA. Group-based trajectory modelling can be used to study the development, thus the stability and change, in the person's level of PA over time. This finite mixture modelling opens up for looking at the "hidden heterogeneity" and the possibility of modelling change over several measurement points, enabling the exploration of linear as well as curvilinear change over time (Nagin, 2014).

A growing body of research has utilised finite mixture modelling to investigate the development of PA from a life course perspective, and the literature was recently summarised in a systematic review (Lounassalo, Salin, et al., 2019). Twenty-seven papers published between 2004 and 2018 were included, six of which utilised objectively measured PA; the rest included self-reported or parent-reported measures of PA, exercise, or sedentary behaviour. The most common number of trajectories identified was three or four, and the trajectory categories identified were: increasers, highly active, active, inactive, decrease from moderate PA level, and decrease from a low level/low active. They found that trajectories describing change were more prevalent during youth, such as a decreasingly active trajectory. Four studies, based on two different Finnish longitudinal data materials, identified trajectories from childhood (Kaseva et al., 2016; Rovio et al., 2018) or adolescence (Kiviniemi et al., 2016; Oura et al., 2016) to adulthood. All studies modelled the trajectories based on leisure-time physical activity measures computed based on several items related to sports and activity where the respondents sweated or got out of breath. The largest proportion of individuals was in trajectories describing either persistent leisure-time physical activity (Kaseva et al., 2016; Kiviniemi et al., 2016; Oura et al., 2016) or low leisure-time physical activity (Rovio et al., 2018). In the study by Rovio et al. (2018), five trajectories were identified, namely persistently active (6.6%),

decreasingly active (13.9%), increasingly active (13.5%), persistently low active (51.4%), and persistently inactive (14.6%). This was the only study identifying an increasingly active trajectory from childhood to adulthood. The increasers had a similar leisure-time physical activity level as the low active and inactive participants at the age of 12. However, from here, the increasers differed and increased their level of leisure-time physical activity up to the level of those following the persistently active trajectory. After the above-mentioned systematic review (Lounassalo, Salin, et al., 2019) was published, Lounassalo et al. (Lounassalo, Hirvensalo, et al., 2019) published a paper based on the same data material as Kaseva et al. (2016) and Rovio et al. (2018). Here four trajectories were identified among men, and five were identified among women. Overall, the same types of patterns were identified. However, the increasingly active trajectory was only identified among women.

Among the studies identified in the previously mentioned systematic review, none of the studies from adolescence to adulthood had investigated *enabling factors* such as engagement in different activity domains. Previous studies based on longitudinal data have identified positive effects of several activity domains on PA over time.

Engagement in organised and non-organised PA, team and individual sports, and a wide variety of activities during youth contributes to PA in adulthood. A previous trajectory study identified patterns of objectively measured MVPA from age 15 to 19, and found that sports club participation decreased in all the trajectories, except for the increasingly active trajectory (Aira et al., 2021). Kjønniksen, Anderssen and Wold (2009) found, based on data from the NLHB study, that age at becoming a member in organised sports and the number of times reporting to be a member during adolescence predicted 9% of the variance in LVPA at age 23. A Finnish study found that persistent participation in sports in particular, predicted adult PA level (Telama et al., 2006). Previous studies have also found that greater diversity of leisure-time activities in adolescence seems to have an enabling effect of increased leisure-time PA in adulthood among females (S. Mäkelä et al., 2017), and that the number of activities participated in at age 15 was stronger related to LVPA at age 23 than was participation in specific activities (Kjønniksen et al., 2008). Outdoor recreation is a broad term and includes different types of activities, and previous research has found

that outdoor PA contributes more to positive attitudes towards PA and contributes to positive activity habits (Eigenschenk et al., 2019).

Multiple studies show that adolescent PA is related to parental PA, confirming that parents may be important role models and reinforcing factors for PA (Messing et al., 2019; Sluijs et al., 2021).

A few previous studies have looked at possible determinants or predictors of PA trajectory membership (Barnett et al., 2008; Rovio et al., 2018). Both studies found that being male increased the odds of belonging to a persistently active trajectory compared to an inactive or low active trajectory. Higher grade point averages (Rovio et al., 2018), higher levels of education and higher household income (Barnett et al., 2008) were associated with being in more active trajectories. Rovio et al. (Rovio et al., 2018) found that parents' PA when the respondents were age 12 increased the odds of belonging to a decreasingly active trajectory compared to a persistently low active trajectory.

Identifying heterogenous development across the life course is valuable for increasing the knowledge of the stability and change in activity behaviour, and examining factors related to those trajectories is essential for developing well-targeted PA promotion. As more trajectories related to change are identified in youth, it seems eminent to investigate processes related to adolescence to further increase the knowledge on stability and change in LVPA over time.

4. The overall aim of the thesis

To develop, plan and implement a successful program for health-promotive physical activity, there is still a need for an increased understanding of the factors underlying exercise and physical activity in a particular situation.

We are examining the factors contributing to PA development over time by utilising survey data collected over the past four decades. The overall aim is thus to study stability and change in LVPA from both an individual perspective and a group level.

This is further explored in the three papers and their specific research aims:

Paper I aimed to identify distinct trajectories of LVPA and to explore whether these trajectories were characterised by differences related to activity domains over the life course. The activity domains included participation in organised sports, diversity in leisure-time activities, outdoor recreation, and active peers.

Paper II aimed to examine how demographic (gender, family income, BMI), psychological (intentions, enjoyment, self-efficacy, self-determination, competence, value, athletic identity) and social (parental physical activity, support, and encouragement) factors in early adolescence could predict membership in four distinct LVPA trajectories (identified in paper I) from 13 to 40 years.

Paper III aimed to examine changes from 1985 to 2014 in self-reported participation in organised sports clubs and LVPA among Finnish and Norwegian children and adolescents and to what extent the association between self-reports of participation in organised sports clubs and adolescents' LVPA levels have changed over time in the two countries.

5. Methods

5.1 Design, sample and procedures

In order to answer the overarching research questions of this thesis, data from two ongoing studies initiated at the University of Bergen were used. First, data from the Norwegian Longitudinal Health Behaviour (NLHB) study was utilised to explore the heterogeneity in the development of LVPA from early adolescence to adulthood and how those belonging to the distinct developmental trajectories reported engagement in different activity domains and if demographic, psychological and social predictors differed between the groups. Secondly, nationally representative, repeated cross-sectional data from the Health Behaviour in School-aged Children (HBSC) study was used to study secular changes in LVPA and participation in organised sports clubs from the 1980s to the 2010s and to see if the association between them had changed over this period of time.

Both repeated longitudinal and cross-sectional studies are needed to understand change over time, as they provide information about both individual and societal change (Firebaugh, 2010).

5.1.1 Norwegian Longitudinal Health Behaviour (NLHB) study (paper I and II)

Paper I and II use data from The Norwegian Longitudinal Health Behaviour (NLHB) study, a 27-year prospective two-generational cohort study on self-reported health behaviours and lifestyles related to health and well-being.

The study follows the participants from age 13 in 1990 to age 40 in 2017, in all ten times, and their parents (measured at three-time points in 1990, 1993 and 1996). See Table 1 below for the number of participants and age at each data collection. The sample was drawn from 22 randomly selected schools (54 classes), picked systematically from an alphabetical list of all schools in a region on the west coast of Norway (the former county Hordaland). The sample was limited geographically to this region to allow close contact with the participating students in the crucial early

phase of the project. At the first data collection in 1990, nine hundred and twenty-four students participated. This was 77% of the 1195 students initially invited to participate. Excluded from this sample were those whose parents did not give their consent for participating or who failed to return the consent form (n=222), those who did not wish to participate (n=46), and those who provided unusable responses (n=3).

Any new students in the included schools in 1991 and 1992 were invited to participate, increasing the total number of students invited by 47, resulting in a total sample of 1242. Twenty-nine did not participate in 1990, 1991, or 1992 but participated at least once during the data collections between 1993 and 2017.

For the data analysis in paper I and II, participants with at least one measurement of LVPA over the ten measurement points were included. This reduced the included sample to 1103 participants (45.5% female).

Table 1

Measurement years, age and total number of participants per measurement year.

	1990	1991	1992	1993	1995	1996	1998	2000	2007	2017
Age	13	14	15	16	18	19	21	23	30	40
N	924	958	936	789	779	643	634	630	536	455

Before the survey, parents or caregivers were informed and gave written consent for participation. Participants were surveyed ten times (1990, 1991, 1992, 1993, 1995, 1996, 1998, 2000, 2007, and 2017). The survey was conducted during school hours for the first three times, and the students completed the self-completed questionnaires in class. After that, the questionnaire was distributed by post. Participants were also given the option to respond online for the last two surveys. The questionnaire was distributed in October when the survey was conducted in school. Later when the questionnaire was sent by post, there was greater variation in the time of completion.

The study has been approved by the Data Protection Official for Research at the Norwegian Center for Research Data, assuring that the study complies with the ethical requirements for privacy and confidentiality.

5.1.2 Health Behaviour in School-aged Children (HBSC)

Paper III used data from the Health Behaviour in School-aged Children (HBSC), a WHO cross-national survey. This international repeated cross-sectional study has been ongoing since 1983/84. With an increasing number of participating countries, it is carried out in more than 50 countries every four years in nationally representative samples of 11-, 13, and 15-year-olds. The aim is to gain knowledge on adolescent health and well-being in their social context (Currie et al., 2014). Paper I presents data from Norway and Finland collected at two different time points in 1985/1986 (November-December 1985 in Norway and February-March 1986 in Finland) and 2013/2014 (March-May 2014 in Finland and March 2014-January 2015 in Norway). Of the 13 countries participating in the survey in 1985/86, only Norway and Finland collected data on participation in organised sports clubs in 1985/86 and 2014 and were included in the analysis.

In Finland, the samples were chosen from the Finnish school register using a special sampling program. The sample frame was the number of pupils at each class level. Schools were selected using a cluster sampling method that took the size of the schools (PPS, probability proportionate to size) into account. Inside a selected school, one class was randomly selected. In Norway, school classes were used as primary sampling units, with a standard cluster sampling procedure based on a graphical stratified list and sequential selection from a randomised starting point. If a school agreed to participate, all pupils from one class per age group were selected. Student response rates among participating schools were 89% in 1986 and 85% in 2014 in Finland and 91% in 1985, and 92% in 2014/15 in Norway, respectively.

Following the international protocol of the HBSC study, 90% of the sample in each age group fell between half a year of a mean age of 11.5, 13.5, and 15.5 years. This

led to a total of 16 355 11-, 13-, and 15-year-olds in the included sample from 1985/1986 and 2014.

Before the respondents gave voluntary informed consent and anonymously completed the questionnaire during one lesson period at school, informed passive consent was obtained from the pupils' primary guardians. They were informed that participation was voluntary and about the possibility of withdrawing at any time without a specific reason.

In 1985/1986, the questionnaire was paper based in both countries, as was the questionnaire in Finland in 2014, while the schools could choose a paper-based or a web-based questionnaire in Norway.

At both time points, the Data Protection Official for Research at the Norwegian Center for Research Data assured that the study complied with the ethical requirements for privacy and confidentiality. The Finnish HBSC study was approved by the Finnish Teachers Trade Union and the Finnish National Agency for Education when the survey was collected for the first time in 1986, and the procedure has been the same since.

5.2 Measurements

The measures used in Paper III based on the HBSC study have also been used in paper I based on the NLHBS, and thus the measures will be presented concurrently.

5.2.1 Leisure-time vigorous physical activity

Leisure-time vigorous physical activity was measured with a question regarding the frequency of such activity. The question reads: «Outside school hours, how often do you do sports or exercise to the extent that you become out of breath or sweat?» The following response categories were given (coding in parenthesis): Every day (7), 4–6 times a week (5), 2–3 times a week (2.5), Once a week (1), Once a month (0.25), Less than once a month (0), and Never (0). In the NLHBS, the first part of the

question's wording was changed to «Outside school/work hours» in 1993 and «Outside work hours» in 2017.

This variable was measured at all ten measurement points in the NLHB study and both in 1985/86 and 2013/14 in the HBSC study and is used as the outcome measure in all three papers.

5.2.2 Membership in organised sports clubs

Membership in organised sports clubs was measured using a single item: «Are you a member of a sports club/sports association?» In the HBSC study, the response categories were No (1), Yes, I train in a sports club (2), and Yes, but I don't attend training sessions (3). Some respondents indicated they were members but did not attend training sessions (Finland: $n = 313$ in 1985/1986 and $n = 183$ in 2014, Norway: $n = 258$ in 1985/1986 and $n = 76$ in 2014). Those «passive» members were excluded from the analysis in order to be able to interpret the results more precisely and reflect upon the differences between non-participants and participants in sports clubs. In the NLHBS, the response categories were Yes (1), No, but I have been a member before (0), and No, I have never been a member of a sports club (0). This item was included at eight measurement points (excluded at ages 19 and 21 years). Membership in organised sports clubs is included in papers I and III.

In the NLHBS, the respondents were at ages 13, 14, 15 and 16 given the question «When did you become a member of a sports club?» with response categories being I have never been a member of a sports club or sports association (0) and I became a member when I was about years old, with response options of 1–13, 14, 15 or 16 years. Responses to this question were recoded so that the most initial response was preferred. This measure is included in the paper I.

5.2.3 Diversity in leisure-time activities

A measure of diversity in leisure-time physical activities was computed based on a list of alternative types of sport or exercise at ages 15 (33 alternatives), 23 (33 alternatives) and 40 years (20 alternatives). See the complete list of the types of activities in an appendix. Following the list, the respondents were presented with four

response categories: Several times a week, Once a week, Less than once a week, and Never. Based on this, a count variable was computed where the performance of a sport or exercise at any frequency was counted. This measure is used in the paper I.

5.2.4 Outdoor recreation

The outdoor recreational activity was measured using two questions about outdoor recreation during summer or winter. The questions were: «How often do you usually do out- door activity in summer? Outdoor recreation in summer can include hiking, swimming, cycling, or fishing» and «How often do you usually do outdoor activity in winter? Outdoor recreation in winter can include hiking, fishing or cross-country skiing», with the following response categories: Four times a week or more often (4), 2–3 times a week (3), Once a week (2), Less than once a week (1), and Never (0). These items were included in the NLHBS at ages 13, 14, 15, 16, 23, 30, and 40. This item is used in the paper I.

5.2.5 Peer PA

Peer PA was assessed using two items related to active friends and best friend's activity level, both used in Paper I. The first item related to the number of friends participating in sports and included the question, "How many of your friends do sports or exercise?". The response categories were Almost all (4), More than half (3), About half (2), Less than half (1), and None (0). This item was included at ages 13, 15, and 18 years.

The second peer item related to the level of sports and exercise performed by the participant's best friend and read, "Does your best friend do sports and exercise?" The responses options were Four times a week or more (4), 2–3 times a week (3), Once a week (2), Less than once a week (1), Never (0), and I do not have a best friend (missing). This item was included at ages 13, 15, and 23 years. This item is used in the paper I.

5.2.6 Intentions

Intention for future PA was measured using two single-item questions related to intentions for performing VPA at different levels in one year or ten years. The

question reads, «Think about yourself in one year/ten years. How many times per week do you think you will do sports or exercise to the extent that you become out of breath or sweat?» with the following response categories (coding in parenthesis): Every day (7), 4–6 times a week (5), 2–3 times a week (2.5), Once a week (1), Once a month (0.25), Less than once a month (0), and Never (0). This item is used in paper II.

5.2.7 Perceived competence

Perceived competence in PA was measured as the respondents' assessment of their skills in relation to peers, Perceived competence in sports was measured using the following questionnaire item; «Think about many different sports outside school. How good are you normally in sports?», with response categories (coding in parenthesis): Better than peers (4), Slightly better than peers (3), As peers (2), Slightly worse than peers (1) and Worse than peers (0). This item is used in paper II.

5.2.8 Perceived importance of competence

The perceived importance of sports competence was assessed in the following matter; «How much does it matter to you whether you are good or bad at sports?» It means a lot (3), It means some (2), It means little (1) and It doesn't mean anything (0). This item is used in paper II.

5.2.9 Athletic identity

Athletic identity was measured by asking if the respondent thought of themselves as an athlete. «Do you think of yourself as a sports girl/boy?» with responses Yes (1) and No (0). This item is used in paper II.

5.2.10 Enjoyment in sports

Enjoyment was related to affective judgement and was measured with the question, «How do you enjoy doing sports?» Very much (4), Enjoy it (3), Neither good nor bad (2), Bad (1) and Very bad (0). This item is used in paper II.

5.2.11 Self-efficacy

This measure was related to one's perceived ability to engage in PA, hence task-specific efficacy. The questionnaire item used read as follows; "How easy would it be for you to engage in sports or exercise, should you wish to do so?" with the following response categories; Very easy (4), Easy (3), Neither easy nor difficult (2), Difficult (1) and Very difficult (0). This item is used in paper II.

5.2.12 Self-determination

Self-determination was measured with the following item; "Do you feel that you can decide for yourself how much you are going to participate in sports?". The response categories were I decide for myself a great deal (4), I can decide for myself a lot (3), I can decide for myself to some degree (2), I can decide for myself a little (1) and I cannot decide for myself much (0). This item is used in paper II.

5.2.13 Parental PA

The respondents' perception of the mother's and father's level of sport or exercise was measured using two separate questions. The questions were as follows; «Does your mother/father do sports or exercise?» with response categories; 4 times per week or more (4), 2-3 times per week (3), Once a week (2), Less than once a week (1), Never (0) and I don't have a mother/father (Missing). This item is used in paper II.

5.2.14 PA, together with parents

The following questionnaire item was used to measure whether the respondents engaged in sports and exercise with their parents: "Do you happen to do sports or exercise together with your mother or father?». Response categories were 4 times per week or more (4), 2-3 times per week (3), Once a week (2), Less than once a week (1) and Never (0). This item is used in paper II.

5.2.15 Instrumental support from parents

Instrumental support from parents was measured using one item: "Does it happen that your parents help you do sports? (It can be such things as driving or picking you up, timing, keeping scores or similar.)». The response categories given were; 4 times per

week or more (4), 2-3 times per week (3), Once a week (2), Less than once a week (1) and Never (0). This item is used in paper II.

5.2.16 Emotional support from parents

Emotional support from mother or father was measured in relation to encouragement in two separate questions. The item read as follows; "How often does your mother/father encourage you to do sports or exercise to keep fit?" with the following possible responses 4 times per week or more (4), 2-3 times per week (3), Once a week (2), Less than once a week (1) and Never (0). This item is used in paper II.

5.2.17 Gender

Gender was measured using the following question; «Are you a boy or a girl?» with the response categories being (coding in parenthesis) Boy (0) and Girl (1). This item was used in paper I, II and III.

5.2.18 Body Mass Index

The respondents' height and weight were queried, and self-reported values were used to calculate the respondents' body mass index (BMI). BMI was calculated by dividing the respondents' weight in kilograms by the square of their height in meters. The measure of BMI was included in paper I based on data collected at age 15, 23 and 40, and in paper II based on data collected at age 13.

5.2.19 Having children

A single question related to having children was included in the questionnaire from early adulthood to midlife (age 21, 23, 30 and 40). The respondents were asked: «Do you have children?» The response categories were «No» (0) and «Yes» (1). This item was included in paper I.

5.2.20 Income

In paper I, socioeconomic status was based on a measurement of self-reported gross income at ages 23, 30 and 40 years. The question read, "What was your income in 1999/2006/2016 (gross)?" with response categories in intervals of 100 000 NOK. The response categories started at "Less than 100 000 NOK" (0), and the highest response

category at age 23 was “500 000 or more” (5), while this was increased at age 30 to “700 000 or more” (7), and at age 40 to “900 000 or more” (9).

Paper II used a measure of parental reported household income in 1995. Mother and father were asked; «What was your household's total income in 1995 (gross)?» with response categories (referring to Norwegian kroner) Less than 100.000 (0), 100-199.000 (1), 200-299.000 (2), 300-399.000 (3), 400-499.000 (4) and 500.000 or more (5). This data was used to calculate a mean based on the two or one when there was missing. The new mean measure of family income (n=614) was used as continuous in the analysis.

5.3 Reliability, validity and generalisability

In this thesis, the outcome measure in all three articles is the same single-item measure related to leisure time and weekly vigorous-intensity physical activity frequency. This item has been included in the international HBSC study since the 1980s (Currie et al., 2012) as well as in several international publications. The measure has been found to have acceptable to good reliability in a previous study from Australia (M. L. Booth et al., 2001) and overall good reliability in a sample of Norwegian adolescents (Rangul et al., 2008). The validity of the measure has also been evaluated, and the item has shown medium correlations ($r=0.39$) with maximum oxygen uptake and partial validity, showing higher scores of LVPA for those given higher scores on a 20-m shuttle run test (Rangul et al., 2008).

The measures used in this study are single-item measures. Single indicators have decreased level of detail, unknown reliability, and might not capture needed complexity in psychological constructs (Allen et al., 2022). The single item used to capture LVPA only captured the frequency and not the duration of the behaviour in question. The measure of membership in sports clubs was based on a single question related to membership. It has previously been suggested that this is a reliable and valid way of mapping sports participation in Norway (Kjønniksen, Fjørtoft, et al., 2009), as youth sports are mainly organised within the national confederation for

sports, and youth are likely to know whether or not they are members. However, the item does not measure the frequency or duration of participation, and if we could have included this, it would have strengthened our analysis.

The included questions related to intentions address willingness and behavioural expectations. Such questions have been termed *decisional intention* and include an outcome plan (Rhodes & Rebar, 2017). Self-efficacy and self-determination are commonly measured as latent constructs; it is possible that our single-item measure does not capture the complex psychological construct, and caution should be made in the interpretation of the results pertaining to the predictive power of these constructs. Other measures, such as athletic identity and enjoyment in sports, are considered to be reliable measures as the constructs are less complex, rather one-dimensional clear and straightforward questions. In addition, we argue that the measures have strong face-validity as they are worded similarly to indicators in scales, such as the Athletic Identity Measurement Scale (AIMS) (Brewer et al., 1993) and the Physical Activity Enjoyment Scale (PACES) (Kendzierski & DeCarlo, 1991). Despite the decreased level of detail and unknown reliability, the use of these single-item measures is more cost-effective and parsimonious regarding efficiency and utility (Allen et al., 2022), which have been crucial to the development and ongoing engagement in the longitudinal study, that has been ongoing for 27 years.

The results from paper I and II based on the NLHB study are not necessarily generalisable to other populations. The studied sample represents a population from the western coast of Norway. However, the baseline mean of LVPA at age 13 (in 1990) in the NLHB study sample is almost identical to that of the Norwegian nationally-representative HBSC study sample of 13-year-olds collected the previous year (1989). This similarity suggests that the sample was representative of Norwegian youth in the relevant age group at baseline (Kjønniksen, Anderssen, et al., 2009).

The results from paper III are based on two nationally representative population-based samples from Norway and Finland, following the same protocol with comparable and repeated measurements from 1985/86 and 2014.

5.4 Analysis

In this thesis, a combination of variable-centred and person-centred approaches has been used. In paper I, the primary interest was to explore if there were distinct trajectories, meaning different patterns of development in LVPA; hence a person-centred approach was used. In a person-centred approach, the goal is to group individuals by similarity (B. Muthén & Muthén, 2000). This is done by statistically reducing the “noise” in the data as the total variability is split into *between-group* and *within-group* variability. It is then possible to further look at the differences between those groups. In paper I, differences between the trajectories were explored in relation to involvement in several activity domains. The use of latent class growth analysis (LCGA) opens up for answering research questions that have both person- and variable-centred aspects (B. Muthén & Muthén, 2000). In paper II, a variable-centred approach was used to identify determinants of trajectory membership. Paper III focused on the development of LVPA over time and how this was related to membership in organised sports; hence, the focus was on the stability, change and relation between the variables of interest.

All data were managed, and descriptive statistics and the analysis for Paper III were done using IBM SPSS (version 27.0). For papers I and II, the data were converted to Mplus (version 8.7 (L. K. Muthén & Muthén, 2017)). The level of statistical significance was 0.05.

5.4.1 Missing data in longitudinal studies

As the follow-up in the NLHB study spans over 27 years, some degree of missing is expected. In order to reduce the risk of bias in the results, it is important to identify the missing data level and to determine the mechanisms behind the missingness in the study to handle the missing data the best way.

Within each measurement point, the item- or construct missing level is low in the NLHB study, i.e., those who have responded and returned their questionnaire have replied to most of the questionnaire items. In longitudinal studies with long follow-ups, such as in the NLHB study, participants may be present for some waves of data

collection and missing for others. This form of missingness is called wave nonresponse (Schafer & Graham, 2002). Attrition or dropout are special types of wave nonresponse where the respondent leaves the study and does not come back, and is, in many cases, the most common type of wave nonresponse and can affect a study in different ways. The largest group is often attrition due to discontinued participation (withdrawal), but also because of death or frailty, problems with recontacting the participants (no contact) or non-return (Young et al., 2006). Attrition does not only cause loss of power because of the diminishing number of participants, but it may also reduce the internal and external validity of the findings as the attrition may be selective. However, in many cases, respondents may drop out and reappear. Because repeated measures on an individual tend to be correlated, using all available information for each respondent is recommended, as missing information in parts can be recovered from other measurement points.

In order to determine the best way to handle missing, the mechanisms behind the missingness should be explored. In line with the work of Rubin (1976), there are three mechanisms or distributions of missingness to describe the relationship between measured variables and the probability of missing data (Newman, 2014; Schafer & Graham, 2002): missing completely at random (MCAR), missing at random (MAR), and missing not at random (MNAR). While MCAR results from a process completely unrelated to the variables of interest in the analysis and where the probability of missing is not dependent on the observed or missing data values, MAR and MNAR are considered systematic missingness. The important difference between the two is that in MNAR, the probability that a variable value is missing is dependent on the missing data values themselves, while in MAR, the probability that the value is missing is partly dependent on other observed data in the dataset, but it does not depend on the missing values themselves (Newman, 2014). MAR is also called ignorable nonresponse (Schafer & Graham, 2002), meaning that the reason for missing is unrelated to the study's purpose. However, there is no test for whether the data are MAR or MNAR, and it is impossible to verify without knowing the values of the missing variables.

Several missing data treatments are available, with listwise and pairwise deletion previously being the most common. However, when data are not MCAR, these missing data treatments can produce biased results under MAR and MNAR. With the widespread availability of software that opens for using all available data, multiple imputations (MI) and maximum likelihood (ML) are considered state-of-the-art missing data treatments (Schafer & Graham, 2002). In ML, a likelihood function is used to directly estimate parameters of interest from the incomplete data matrix, as in the full information maximum likelihood (FIML) routine, which yields unbiased parameter estimates and accurate standard errors under the MCAR and MAR mechanisms (Newman, 2014).

In the NLHB study, the response rate at the last follow-up, 27 years after the first data collection, was relatively good, considering the length of the study. Most of the missing data in 2017 is related to wave nonresponse (attrition). To assess this, dropout analyses were undertaken by comparing baseline values of gender, LVPA, membership in sports clubs, age at becoming a member of a sports club, outdoor recreation, number of active friends and best friend's activity level between those who dropped out of the study before age 40 and the 455 respondents who did not. Independent sample t-tests showed no statistically significant differences between these two groups ($p > 0.05$). Family income reported by parents was measured in 1996, and dropout analysis was undertaken for these measures as well. Here a significant difference was found both for family income reported by mother ($t(582) = -3.156, p = 0.002$) and father ($t(543) = -2.215, p = 0.002$), however with small effect sizes based on a Cohen's d of .26 and .19, respectively. Showing that the family income was significantly lower among those who dropped out of the study. Therefore, it does not seem that the data, other than the small difference in parental reported family income, are MNAR. However, it is still not possible to determine if they are MAR, but supported by the low level of item missing, the results from the dropout analysis, and the fact that we have included a comprehensive set of demographical, temporal, and highly correlated variables in the analysis suggest that the potential error is low. Based on this, we assess that the requirements for using FIML to address the missing data are met under the MAR assumption.

5.4.2 Latent class growth analysis (paper I and II)

To explore the number of growth parameters that best suited the data, the data on LVPA from all ten measurement points were modelled in a latent growth model prior to the LCGA. A total of three models were tested. The models had two (intercept and slope factor), three (intercept, slope, and quadratic slope factor) and four (intercept, slope, quadratic, and cubic slope factor) growth parameters, respectively. The best fit, which was determined by the highest comparative fit index (CFI) and the lowest root mean square error of approximation (RMSEA), was obtained when the model included four growth parameters (CFI=0.911, RMSEA=0.05).

LVPA trajectories were identified using LCGA. LCGA is a type of group-based trajectory model, making it possible to identify latent classes of individuals based on their joint growth trajectories over time (Nagin, 2014). The analysis treated the LVPA variable as continuous; missing data were assumed to be missing at random (MAR) and addressed using full information maximum likelihood estimation (FIML). The analysis also included 44 auxiliary variables related to demographics (gender, BMI, income) and activity domains. These variables were used in the distal outcome model described below but were also important in treating missing data. The model parameters were estimated using the maximum likelihood estimator with robust standard errors (MLR).

Akaike information criterion (AIC), Bayesian information criterion (BIC), entropy, average posterior probability >0.70 for within-group membership, the Vuong–Lo–Mendell–Rubin test (VLMR), and the bootstrap likelihood ratio test (BLRT) were used to assess the fit and interpretability of the model, as well as the final number of latent trajectory classes (van de Schoot et al., 2017).

The number of classes was determined by testing the model fit for two, three, four, five, six, and seven latent trajectory classes.

The Guidelines for Reporting on Latent Trajectory Studies (GRoLTS) checklist was used to ensure the quality of the analysis and the reporting. In the class enumeration, the AIC and BIC values did not reach a low point and start to increase as suggested

by the guidelines. The VLMR test was significant only for the two-class and four-class models ($p < 0.05$), but the proposed more reliable BLRT was significant for all models. The enumeration was therefore based on entropy and the posterior probability of class membership in addition to theoretical and empirical support for selecting the four-class solution. Through qualitatively assessing the three- and five-class models vs the four-class model, we found that the three-class solution provided fewer nuances, and the five-class solution had two similar and (almost) parallel classes.

5.4.3 Distal outcome model using the Block–Croon–Hagenaars (BCH) approach (Paper I)

Paper I examined the mean difference in the variables related to activity domains (i.e., membership in organised sports clubs, diversity in leisure-time physical activities, peer PA and outdoor recreation) measured in adolescence, young adulthood and adulthood, across the trajectory classes. To accomplish this, we employed the one-step automatic BCH approach. By utilising this approach to estimate a distal outcome model, we were able to prevent a shift of the latent class trajectories, ensuring that they were still primarily assessed by the LVPA measure. Instead, the BCH approach employs weighted multiple-group analysis in the final stage to avoid any alterations in the latent classes. In the BCH approach, the auxiliary variables are treated as continuous.

5.4.4 Multivariate multinomial logistic regression (Paper II)

To examine the significant determinants of trajectory group membership, we employed several multivariate multinomial regression models. Initially, we utilised the ‘save data’ command in Mplus to generate a novel variable based on the likelihood of belonging to one of the four distinct latent classes. Subsequently, demographic, psychological, and social factors were included as determinants of the latent class membership variable. Finally, we iteratively conducted the multivariate multinomial regression, with each latent class serving as a reference group.

5.4.5 Linear mixed model analysis (Paper III)

To examine the changes over time and gender disparities in participation in organised sports clubs and the level of LVPA, we employed Pearson chi-square and independent sample t-tests. Effect sizes were calculated using Cohen's *d*, with the assistance of the calculator available at www.psychometrica.de.

The main outcome of our analysis was LVPA. We considered five discrete independent factors: country, survey year, gender, participation in organised sports clubs, and age group. To adequately address potential classroom effects, we formulated all models as two-level regression models, incorporating a random intercept for the school class, which was the primary sampling unit. A full linear mixed model, with all main and interaction effects was estimated utilising restricted maximum likelihood. The omnibus significance test for each independent factor was assessed by means of type III F tests using Satterthwaite corrected degrees of freedom. To facilitate interpretation, we estimated the marginal means, examining the simple effects of survey year by country, participation group, gender and age group.

6. Results

6.1 Paper I: Leisure-time physical activity trajectories from adolescence to adulthood in relation to several activity domains: a 27-year longitudinal study.

This paper aimed to identify distinct trajectories of LVPA. Secondly, we aimed to explore whether these trajectories were characterised by differences related to several activity domains, i.e. participation in organised sports, diversity in leisure-time activities, outdoor recreation, and active peers.

Four trajectories were identified: active (9%), increasingly active (12%), decreasingly active (25%), and low active (54%), with heterogeneity in the development from adolescence to adulthood. There was a declining tendency in LVPA from age 13 to 40 years, except for the increasingly active trajectory, which showed a slight increase over the 27-year follow-up. Belonging to the active trajectory, which had higher LVPA levels at all measurement points, was related to higher mean levels on the included measurements related to activity domains. During adolescence, people in the decreasing trajectory reported higher mean levels of participation in and lower mean age at becoming a member of sports clubs, larger diversity in leisure-time activities, and higher best friend's activity level compared with those in the increasing trajectory. However, in young adulthood, people in the increasingly active trajectory reported significantly higher mean levels for the same variables compared to those in the decreasingly active trajectory. The low active trajectory was identified as the largest trajectory group and included more than half the sample (54%). Those belonging to this trajectory reported the lowest mean LVPA level at all measurement points and lower levels on all the included activity domains compared to the other trajectories, showing a stable development from adolescence to adulthood.

6.2 Paper II: Adolescent Determinants of Life-Course Leisure-Time Vigorous Physical Activity Trajectories: A 27-Year Longitudinal Study

Paper II builds upon the LVPA trajectories identified in Paper I by examining how demographic (gender, family income, BMI), psychological (intentions, enjoyment, self-efficacy, self-determination, competence, value, athletic identity) and social (parental physical activity, support, and encouragement) factors in early adolescence can predict membership in the four distinct LVPA trajectories.

The multivariate multinomial logistic regression showed that gender (male), VPA intentions the next year and athletic identity associated with belonging to the two trajectories reporting the highest levels of LVPA in adolescence. VPA intentions in ten years were associated with belonging to the active trajectory compared to the decreasingly active and low active trajectories. Enjoyment increased the odds of belonging to the increasingly and decreasingly active trajectories compared to the low active trajectory. Two of the social determinants, the mother's PA and emotional support from the father, were associated with belonging to the increasingly active trajectory compared to the low active trajectory. Higher family income increased the odds of belonging to the increasingly active compared to the decreasingly active trajectory.

6.3 Paper III: Leisure-time physical activity and participation in organised sports: Changes from 1985 to 2014 in Finland and Norway

The third paper examines changes from 1985 to 2014 in self-reported participation in organised sports clubs and LVPA among Finnish and Norwegian children and adolescents. In addition, the association between participation in organised sports clubs and adolescents' LVPA levels was also examined as to whether this had changed over time in the two countries.

Overall, participation in organised sports clubs and the level of LVPA changed in the same direction in the two countries. There was an increase in the proportion of 11-year-olds reporting to be participants in organised sports clubs from 1985/1986 to 2014. This was also found among Finnish 13- and 15-year-old girls; however, among both Norwegian and Finnish boys aged 15, there was a decrease in participation in organised sports clubs. We found an overall increase in self-reported LVPA, but this was not significant among Finnish boys aged 13 and 15. The association between participation in sports clubs and LVPA was stronger in 2014 than in 1985/1986. The findings indicated subgroup differences. We found only a significant increase in LVPA over time among those reporting to be members of organised sports clubs, except among Finnish non-participating girls aged 11 and 15, where there also was a significant increase in LVPA over time.

7. Discussion

This thesis explored the stability and change in leisure-time vigorous physical activity in Norwegian survey data collected over the past 30 years. This discussion will start by presenting the main findings from this thesis, followed by a discussion of the heterogeneity in the development of LVPA. After that, the results of the three papers will be discussed in light of the YPAP model, focusing on the identified factors that can contribute to the stability and change in LVPA over time.

7.1 Summary of the main findings

1. Four distinct LVPA trajectories were identified in the sample from the NLHB study. These were low active, decreasingly active, increasingly active and active (paper I and II).
2. All trajectories showed a decline in LVPA from adolescence to adulthood, except the increasingly active trajectory, which showed a slight increase (paper I). From adolescence to young adulthood (13-21 years), all trajectories showed more remarkable change than in the period from young adulthood to midlife (21-40 years), which was characterised by a more stable development (paper I).
3. The heterogeneity in the development of LVPA was also present in the development of reporting on several activity domains, namely participation in organised sports clubs, engagement in a diversity of activities, having active peers and time spent on outdoor recreation.
4. Demographic, psychological and social determinants for trajectory group membership were identified, supporting previously highlighted important determinants for adherence to LVPA in a longitudinal perspective, namely intentions for VPA, enjoyment in sports, parental support and encouragement and male gender.
5. Adolescent LVPA and sports participation have changed from 1985 to 2014 in Finland and Norway. We identified differences related to this change among different subgroups of the Finnish and Norwegian samples.

7.2 Heterogeneity in the Development of LVPA from Adolescence to Adulthood

Tracking studies have previously identified low to moderate associations between former and later activity levels (Hayes et al., 2019; Telama, 2009). In paper I, based on a Norwegian population from the west coast of Norway, active, decreasingly active, increasingly active, and low active trajectories of LVPA were identified from age 13 to age 40. The number and size of the trajectories correspond with those identified in previous studies (Lounassalo, Salin, et al., 2019), thus confirming the heterogenic development in PA and contributing to the knowledge related to longitudinal development both between and within individuals. However, these trajectories are based on a selection of different measures related to leisure-time PA, and therefore one should be careful when comparing these trajectories to our trajectories of LVPA.

A tendency of stabile development is evident in the largest trajectory group, i.e., the low active trajectory. Following the low active trajectory was associated with the lowest mean LVPA level at all measurement points. These results support the systematic review of distinct trajectories of PA by Lounassalo et al. (2019), where low active trajectories appeared to be more stable than more active trajectories, as well as supporting previous tracking research showing that inactivity tracks better than activity. The proposed habit formation hypothesis by Telama (2009) can be used in understanding this development, as it seems they have the habit of low levels of LVPA all the way from adolescence into adulthood. The larger low active trajectory and the relatively stable development from adolescence to adulthood are, in addition, consistent with previous research reporting high prevalences of not meeting the PA recommendations in the adult population globally (Guthold et al., 2018) and nationally in Norway (30.9% of 35-49 year-olds in 2013-2014) (Hansen et al., 2015).

In Paper I, we also identified two trajectories starting at a higher level of LVPA, namely the active and the decreasingly active trajectories, representing 9 and 25 per cent of the sample, respectively. Rovio et al. (2018) also identified two trajectories with a higher average level of leisure-time PA at age 13, the persistently active

(6.6%) and the decreasingly active (13.9%). Although not possible to compare related to the level or intensity of PA, the trajectories are proportionally related and follow a similar development from adolescence to midlife. The reasons why the active and the persistently active trajectories reported higher levels of activity than the other trajectories can be related to some kind of hereditary disposition to fitness and motor performance, as in the self-selection hypothesis (Telama, 2009). They increased their level of PA in adolescence before it decreased during adulthood. In contrast, the two decreasingly active trajectories show a steeper decline in activity before a more stable decrease follows in adulthood. When transitioning from adolescence to young adulthood, the types of activities available change and other life-changing events may occur, such as starting education or moving out from parents. As indicated in the carry-over value hypothesis (Telama, 2009), this can contribute to a decrease in activity as such changes can make continuing PA difficult. There are, however, some differences between the two samples. While the persistently active trajectory in the study by Rovio et al. (2018) shows almost the same high level of activity at age 39 as at age 12, the active trajectory in paper I show a lower level of LVPA at age 40. One possible reason could be the difference in measures, or the change in the Finnish study's activity measure used between adolescence and adulthood.

There were also similarities between the Rovio et al. (2018) paper and paper I related to the low active trajectory (54%) and the increasingly active trajectory (12%). In paper I, these trajectories started at the same low level, as did the two trajectories in Rovio et al. (2018), identified as increasingly active (13.5%) and persistently inactive (14.6%). The increasingly active trajectories are interesting to health promotion as they indicate the possibility of change within the formative years of adolescence. These “late bloomers” increased their activity level when the three other trajectories decreased. It is possible that they have entered different activity domains later and that this possibly has increased their abilities, readiness and enjoyment in order to continue to be active over the transitions from adolescence to young adulthood and further, in line with the ability and readiness hypothesis (Telama, 2009).

In sum, there are many similar developmental trajectories in the two samples. This supports the identification of meaningful trajectories of PA from early adolescence to adulthood and the usefulness of such identifications. However, comparability should be done with caution in relation to group-based trajectory modelling. Results must be interpreted in relation to the connected entropy and posterior probabilities, as the classification of trajectories is not definite.

Both the trajectories identified in Paper I and the trajectories from the paper by Rovio et al. (2018) showed changes in the level of PA during adolescence. This change also gave the direction for the development into adulthood among all the trajectories, reflecting the considerable potential for change and the critical period for maintenance of LVPA that is found in the adolescent years.

By utilising the four patterns of LVPA trajectories from adolescence to adulthood, it is possible to explore what characterises individuals with a higher probability of following a given pattern. This information can help build knowledge about factors that might contribute to the stability or change in LVPA over the life course.

In the following sections, the YPAP model will be used as a conceptual framework for discussing various predisposing, reinforcing, and enabling factors that might contribute to the stability and change in LVPA over time. The three papers in this thesis identify factors in the enabling, predisposing, reinforcing and personal demographic components of the YPAP model, and the findings are illustrated in Figure 2. However, far from all possible factors that predispose, reinforce, and enable the development of LVPA are included. Thus, the interpretation of the results should be viewed as contributing to the development of knowledge related to the heterogeneity in LVPA over time rather than a complete demonstration of the processes identified by Welk (1999) for promoting PA.

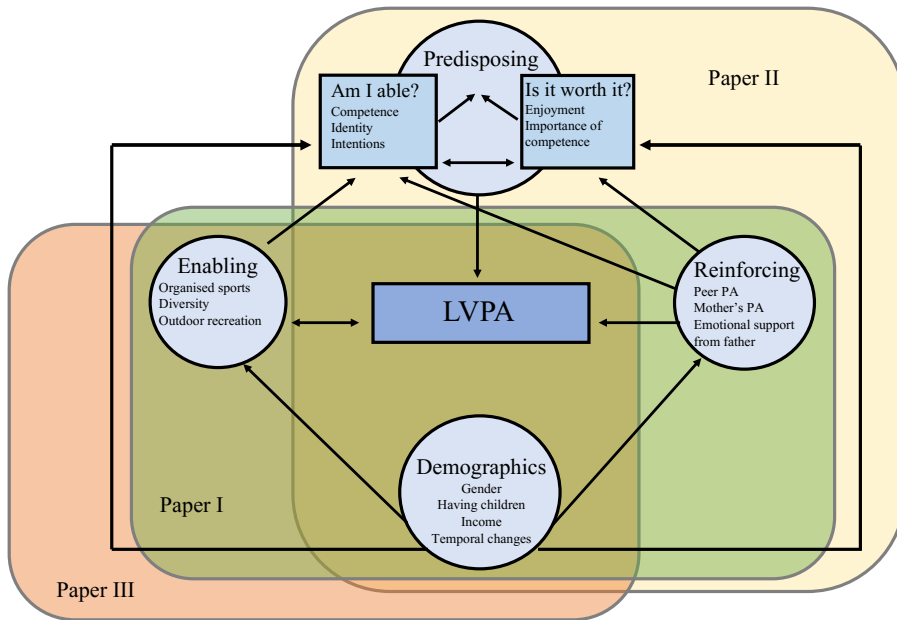


Figure 2 Modified YPAP model showing the focus of the three papers

7.3 Predisposing factors for LVPA development

In paper II, we included a set of psychological determinants, both cognitive and affective. The YPAP model combines cognitive and affective determinants of PA behaviour within the predisposing factor, conceptualised as the two components «Am I able?» and «Is it worth it?» (Welk, 1999). Within the cognitive determinants, VPA intentions in one year and ten years contributed as significant determinants, but interestingly there were some differences. When the respondents were asked about their intentions to engage in VPA the following year, higher intentions significantly increased the odds of belonging to the two most active trajectories compared to the two less active trajectories at age 13. However, when the question about intentions was related to how much VPA they thought they would engage in ten years later, i.e., in young adulthood at age 23, there were significantly lower odds of belonging to those following the decreasingly active trajectory compared to the active. It seems that their assessment of their ability to be active was forward-looking. Intentions are found to be important contributors to overall PA levels (Cortis et al., 2017).

According to the TPB, intentions are guided by behavioural, normative and control beliefs (Ajzen, 2002). The YPAP model highlights how enabling and reinforcing factors influence the individual's perception of whether they are able or not to perform the behaviour. Behavioural beliefs are probably shaped by their interaction with their environment, such as participation in organised sports where opportunities for developing abilities and skills are present, in line with the ability and readiness hypothesis proposed by Telama (2009). Support from family, coaches and friends will probably contribute to the normative beliefs and thus contribute to the development of intentions. This interplay between the predisposing, reinforcing and enabling factors illustrates the complexity of promoting PA.

We found that higher levels of enjoyment in sports increased the odds of following the increasingly active trajectory, whose development during adolescence was characterised by change, compared to those in the stable low active trajectory. As suggested by the SDT, enjoyment increases the motivation to engage in PA because it is intrinsically rewarding.

The connections between the «am I able?» and «is it worth it?» components are vital. People will likely value what they are good at and pursue what they value. Welk (1999) proposes that when answering “yes” to both questions, it is likely to inhabit an athletic identity. Because identity, as outlined by SDT, can affect the regulation of behaviour, a strong athletic identity can be an essential psychological determinant of lifelong PA if the activity becomes a defining element of one's self-identity (Reifsteck et al., 2016). However, we found that a stronger athletic identity also increased the odds of following the decreasingly active trajectory compared to the increasingly and low active trajectories. Several reasons might explain this. Cognitive determinants, such as athletic identity, may not predict lifelong PA development because it is more related to the activity behaviour than and there. Those not as active at the measurement time do not see themselves as athletes. However, this might change. As those in the decreasingly active trajectory become less involved in sports and other activities, it is likely that their perception of themselves as athletes will change. The possible importance of self-identity, as outlined by the SDT, might not

be captured in our measure of athletic identity and thus not predicting lifelong LVPA. In addition, it is possible that our measure did not determine trajectory membership because our trajectories were related to LVPA and not sports activities in particular.

7.4 Reinforcing factors for LVPA development

According to Welk (1999), the reinforcing factors related to PA are those that support PA behaviour and are related to social determinants such as parental support (paper II) and peer support (paper I). In paper I, peer PA was included in the analysis as an activity domain because we wanted to explore the possibility of different domains contributing differently to the four LVPA trajectories. However, related to the YPAP model, if the level of PA among peers or the number of active friends contributes as enabling or reinforcing factors on trajectory membership and thus the development of LVPA from adolescence to adulthood is not clear-cut. The two single-item measures are related to the level of peer PA and the number of active friends, measures not tapping into such factors as support, encouragement or role modelling directly. However, in light of theory, previous research and our findings, it seems like these two measures tap into possible reinforcing contributions of support on the stability and change in LVPA.

Peers can affect PA behaviour through reinforcing mechanisms across, and in addition to, several different activity domains. Both the presence of and the interaction with peers may contribute to an increase in the level of LVPA. We found that the reported level of best friend's PA increased from adolescence to young adulthood for those in the increasingly active trajectory. At the same time, this decreased among those in the decreasingly active trajectory (paper I), which supports previous research and highlights how peer relations should be included in health promotion interventions (Sawka et al., 2013).

As suggested by the SCT, parents constitute essential role models for observational learning of behaviour and attitudes (Bandura, 1986). Having a more active mother increased the odds of belonging to a trajectory where the level of LVPA increased

during adolescence and continued at a higher level through adulthood (paper II). As indicated in the YPAP model, reinforcing factors related to parental support can affect LVPA directly or indirectly through the predisposing factors. The influence of parental PA on LVPA trajectory membership can, in addition to modelling, also be related to support and encouragement. We found that higher levels of encouragement from fathers increased the odds of belonging to the increasingly active trajectory compared to the low active trajectory (paper II). The supportive encouragement for PA might have strengthened the motivation to initiate and maintain PA in the increasingly active trajectory through this indirect path. Previous research has identified parental influence, such as support, as crucial for children and adolescents' PA (Messing et al., 2019; Sallis et al., 2000; Sluijs et al., 2021), and our findings indicate that this could be an essential factor in relation to the positively changing trajectory.

7.5 Enabling factors for LVPA development

The enabling factors in the YPAP model facilitate activity (Welk, 1999), and are such things as access to equipment, parks, programs or organised sports clubs. These enabling factors are necessary for LVPA but not sufficient, as youth can have access to but not make use of them. Paper I and III both include measures of membership in organised sports clubs. The results indicate that participation in organised sports can act as an enabling mechanism for achieving higher levels of LVPA. Organised sports provide both environmental attributes, as in the physical context where the sport is being done but could also be important in relation to the biological attributes described by Welk (1999). Previous research has found that those participating in organised sports show greater physical skills, which can be both an essential predisposing factor and an outcome of increased participation. This type of reciprocal relationship can be important for developing active LVPA patterns across different life phases.

The results from paper I show that those belonging to the active trajectory were characterised by reporting higher involvement in different contexts that can be

considered enabling for LVPA over time, namely outdoor recreation, diversity in leisure-time activities and membership in organised sports clubs. It is possible that their engagement in these domains contributed to their possibilities for being active in LVPA, in line with previous research identifying such environmental factors as important determinants for PA (Sterdt et al., 2014), and thus directly influencing the level of LVPA. Engagement in organised sports or a range of different leisure-time physical activities opens up the development of skills and abilities, and the YPAP model, the hypothesis by Telama and previous research has suggested that previous experiences and the basic skills connected to it can contribute to maintaining PA behaviour over time (Engström, 2008; Telama, 2009).

As pointed out by Welk (1999), the enabling factors are essential for PA but not sufficient. Almost half of those in the low active trajectory participated in organised sports at age 13; however, this did not contribute to higher levels of LVPA (paper I). Similar findings have been reported for trajectories based on objectively measured PA in a youth sample in Finland (Aira et al., 2021). There are several reasons why membership alone in organised sports did not contribute to higher levels of LVPA in line with the enabling factor in the YPAP model. One reason could be related to the measurement, which only questions whether the respondents are members. They may be members of an organised sports club but seldom participate. This can be related to negative experiences or low levels of enjoyment and motivation related to LVPA.

The results from paper III showed that in both Finland and Norway, there was a decrease in the level of participation in organised sports clubs from age 11 to age 15 at both measurement points. This decline with age was also found in the longitudinal data, and the dropout was especially large among those in the decreasingly active trajectory (paper I). Such decline with age has been documented in several previous studies and might be related to high demands for achievement or low perceived competence (Crane & Temple, 2015). Such possible reasons for dropout should be further investigated in longitudinal studies, as the possible positive impact of greater retention on the LVPA level over time seems significant, and also studies looking at

what the specific factors that enable PA within organised sports are, such as motivation, autonomy support from coaches, interaction with peers etc.

Lastly, the secular changes found in paper III related to the enabling role of organised sports clubs should be considered in relation to the findings from paper I and II. In paper III, we found an increase in the level of participation among the 11-year-olds and a decrease in the level of participants at 15 years old. In addition, we found that there had been an increase in the self-reported level of LVPA among participants of all ages in 2014. This could indicate that the development of LVPA patterns in adolescence in the 2010s would look different than the trajectories we found. There might be even more considerable differences between the trajectories at age 13 in the level of LVPA, and perhaps will the decrease in LVPA be even more considerable among those not participating in organised sports. However, it is also possible that secular changes with an increased focus on healthy lifestyles and participation in keep-fit activities might have contributed to increased levels of LVPA outside organised structures (Gilchrist & Wheaton, 2011; Westerståhl et al., 2003).

7.6 Demographic factors related to LVPA development

In this thesis, we found that demographic factors should be considered in the development of LVPA because they directly influence how particular individuals respond to the various influences proposed by Welk (1999).

There were more men in the active and decreasingly active trajectories (paper I and II), which is consistent with previous reports (Aira et al., 2021; Barnett et al., 2008; Rovio et al., 2018), and studies showing that the level of PA decreased more among boys than girls in adolescence (Corder et al., 2019). In paper III we also found that the gender difference in LVPA was greater among 11-year olds than among 13- and 15-year-olds. In addition, we found that the gender difference in Finland decreased over the four decades, finding no significant gender difference between 13- and 15-year-old in 2014. This was found to be related to an increase in the level of LVPA among girls.

Further, higher family income was related to a higher likelihood of following the increasingly active compared to the decreasingly active trajectory (paper II). The effect we saw on the mother's PA and emotional support from the father may be an effect of higher socioeconomic status and more available resources to support the respondents who followed the increasingly active trajectory and changed their level of LVPA during adolescence. In adulthood, we found that self-reported income was higher among those in the active trajectory compared to the other three trajectories at age 30, indicating that those following this consistently active trajectory might have had more economic stability and more resources to invest in LVPA. However, it is also possible that these differences are confounded by the analysis not being controlled for gender, as the active trajectory consisted of 80% men.

At age 21, more respondents in the low active trajectory had a child compared to the active and increasingly active trajectories. Previous research has found that having a child is negatively associated with overall PA (Condello et al., 2017), that having a child increases the odds of belonging to a decreasingly active trajectory (Rovio et al., 2018) and that there is a negative effect on the number of sports one participates in among women (van Houten et al., 2019). Having kids may affect one's ability or the availability of formerly used arenas for LVPA, such as organised sports clubs. Further, it might also change the individual's perception of the value of the activity, i.e., if it is “worth” it.

In addition to these demographic differences, this thesis also found differences that may illustrate cultural differences related to secular changes.

In paper III, we found that the importance of the enabling domain of organised sports had changed over the four decades from the 1980s to the 2010s. Increased commitment and frequency can indicate that the importance of participation in organised sports for higher levels of LVPA had increased from 1985/1986 to 2014. Macro-environmental and demographic changes over the last four decades, such as less space for spontaneous PA, increased preferences for safe and structured

activities, and decreased gender differences in participation, might have influenced children and adolescents' LVPA behaviour.

Further, there have also been changes related to the reinforcing factors over time, specifically in the parental involvement related to LVPA. Increased parental involvement in youth's participation in sports has previously been identified and considered a generational change. Since the 1980s, parental involvement in sports has gone from supporting the youth's participation in organised sports clubs to being hands-on, involved and emotionally invested in organised sports (Stefansen et al., 2018). This cultural change may have led to the observed increase in the association between participation and level of LVPA among children and adolescents in paper III, as parents encourage and arrange for participation in sports clubs. In addition, these findings from paper III indicate that the significant determinants related to parental involvement found in paper II can have increased in strength since the 1990s. On the other hand, there might have been an increase in parental involvement among the whole generation of parents, making parental involvement not a predictive factor for trajectory membership, as it becomes more of a common trait of modern parenting.

In addition to changes in the reinforcing factor of parental involvement, changes in the collective value of sports and health-promoting behaviour may have led to changes in the predisposing factors, especially related to the "is it worth it?" component. Increased focus on leisure time and sports, both in media and public policy, may have increased the value of sports as a significant investment for leisure and health.

7.7 Strengths and limitations

The main strength of the present thesis is the longitudinal design, long-time follow-up with multiple measurement points, comprehensive use of the same self-reported measures in papers I and II, and the relatively large and population-based samples with comparable and repeated measurements from Finland and Norway in Paper III.

One of the limitations of this thesis is the use of a single, self-reported item in the assessment of the outcome variable in all three papers, LVPA. Using a single item might have oversimplified the complexity of this health behaviour, as factors such as duration or type of activity were not measured. Self-report can lead to over- and under-reporting (Katzmarzyk & Tremblay, 2007), and previous research has found that inactive respondents overreported their moderate-to-vigorous PA when comparing self-report to accelerometer data (LeBlanc & Janssen, 2010). Self-report might also be affected by recall bias or the respondents' desire to give socially desirable answers (Brener et al., 2003). Many of these limitations could have been avoided by using an objective measure of LVPA. However, when the HBSC and the NLHB studies were initiated in the 1980s, objective measures were not commonly used within this research field. Lastly, the aim of the three papers in this thesis was not to capture a quantified and precise measure of LVPA but to capture the stability and change among groups of participants within the study populations.

In addition to the measure of LVPA, the other measures used in this study were single-item measurements. Such measures may have decreased levels of detail, unknown reliability and might not capture the intended psychological constructs (Allen et al., 2022). Therefore, caution should be taken in interpreting the non-significant results related to, among others, self-efficacy and self-determination, as these are commonly measured as latent constructs. Many of the other included measures of adolescent determinants are less complex constructs. Single items will likely appropriately measure the intended constructs; if so, scales may not necessarily be favourable (Bowling, 2005). When single items capture what they intend to measure, they are vastly more cost-effective and parsimonious regarding efficiency and utility (Allen et al., 2022).

As the NLHB study followed the same group of participants for 27 years, the amount of missing data is relatively high. From the original sample, many participants dropped out of the study, especially when the study was no longer conducted in school, and some returned at later measurement points. The high level of missing increases the risk of bias and the loss of data. To reduce these risks, possible reasons

for missing were explored and assumed to be MAR, and thus handled using FIML with auxiliary variables in the analysis, keeping as much of the available data as possible, which has been shown to reduce the chance of inadvertently omitting an important cause of missingness, and it also increases efficiency and reduces bias (Collins et al., 2001). The dropout analysis showed mostly insignificant differences between those who dropped out at the last measurement point and those who remained, except for parental reported family income, indicating that the remaining sample had parents with slightly and probably negligible higher reported income. However, some caution can be made in the interpretation of the results in relation to family income.

Further, in group-based models, one reduces by approximation and grouping, comparing individuals that are not entirely homogenous (Nagin, 2014). Therefore, it is essential to recognise that trajectory group membership is not definite because the LCGA gives only the probability of following a trajectory. Long intervals between measurement points can also affect the number of trajectories found (van de Schoot et al., 2017). A critique of data-driven methods for modelling longitudinal data is that the lack of a priori hypothesis related to the number of latent classes results in groups that, in reality, are not there (Bauer & Curran, 2003). The enumeration process is based on a set of formal criteria but also subjective assessments, which can lead to selection bias. Because of this, we followed and reported according to the GRoLTS-Checklist: Guidelines for Reporting on Latent Trajectory Studies to ensure transparency and produce trustworthy and replicable findings (van de Schoot et al., 2017).

8. Conclusion and implications

This thesis showed that the development in LVPA over the past four decades is heterogenic, identifying subgroups in both longitudinal and repeated cross-sectional data. When planning and implementing health promotion to increase levels of PA, knowing that “one size does not fit all” will aid in the specificity and possible effect of interventions.

This thesis revealed that secular changes have moved in the same direction in the two Nordic countries, with an overall increase in self-reported LVPA. However, on a subgroup level, the increase in LVPA seems to have been among girls in Finland and among participants in sports clubs in Norway. This adds to the significance of studying subgroups to understand secular changes in modern society better.

Trajectory modelling is a tool for understanding complex development and the need for well-targeted interventions on subgroups. It balances comprehensibility against the needed exploration of complexity and provides a tool for communicating patterns in longitudinal data by creating dense descriptions of groups of people over time (Nagin, 2014).

This study adds to a relatively unexplored field by exploring a wide range of multidimensional determinants in relation to trajectory membership, which identified possible demographic, psychological and social determinants of following one trajectory compared to the others.

Organised sports are said to contribute to lifelong PA by providing structures for social interaction and the development of skills. However, engagement in organised sports in adolescence did not have a sustainable carry-over value on the level of LVPA later in life for all. Although a large proportion of children in the Nordic countries participate in organised sports, most young people drop out in their early teens. For organised sports clubs to contribute to lifetime LVPA and promotion of public health, there needs to be more awareness of drop-out and retention.

In this thesis, we have measured weekly LVPA and looked at the heterogeneity, domains and determinants related to this context, intensity and frequency of PA. Our results are related to this and may be very different from what contributes to MVPA, total PA or other domains, such as active travel. The knowledge is specific to the context and behaviour. It echoes the need to understand and define PA in relation to culturally specific spaces and contexts and explore the different influences of interests, emotions, ideas, instructions and relationships (Piggin, 2020).

8.1 Implications for practice

Among the four trajectories identified, the absolute largest was the low active trajectory, representing 54% of the total sample. There is great potential in identifying measures that could promote and increase the activity of those with an increased probability of following such trajectories during adolescence. As those following such trajectories are similar to those in the increasingly active trajectory, there is promise in the possibility of engaging in and forming new habits related to LVPA during this period in life. Efforts should be made to introduce adolescence to activities within different enabling structures, such as organised and non-organised sports, outdoor recreation, and physical education in schools.

In addition to supporting entering activity domains at a later stage in adolescence, efforts should also be made to reduce the drop-out from organised sports. Naturally, as the core of sports is related to competition, there might be an increasing focus on performance as adolescents grow older. This can motivate some, while it can make others leave organised sports. Collective efforts should be made to ensure there are possibilities of continuing LVPA during adolescence within and outside organised structures.

We found that the development of peer PA followed in the same direction as the LVPA trajectories. The reinforcing factors related to friends should be included in interventions as efforts to increase LVPA can benefit from focusing on the adolescents' and adults' social networks.

The findings support the use of a conceptual model such as the YPAP model to build a bridge between theory, research, and practice. This is also related to the use of LCGA, as the trajectories «make sense» in the real world and are easily understood by practitioners. In health promotion, one of the core aims is to advocate and make knowledge available. This includes the use of simple, usable, and heuristic frameworks and the dissemination of understandable results.

In addition to the enabling, reinforcing, and predisposing factors in the YPAP model, greater focus should also be on the built environment and policies related to youth PA, as is emphasised in socioecological models. This includes safe alternatives and possibilities for active transport, leisure-time activities and sports.

8.2 Suggestions for future research

There is a growing body of research using group-based trajectory modelling to investigate the development of PA from adolescence to adulthood. However, we have only been able to identify studies based on two other longitudinal data materials, both from Finland. There is a need for new trajectory studies from adolescence to adulthood based on cultural contexts other than the Nordic.

Because of the known limitations related to self-reported PA, such as under- and over-reporting, recall bias or social desirability, future research should aim at using objectively measured LVPA in longitudinal studies. This will increase the reliability and validity of studies aiming to understand the stability and change in LVPA from adolescence to adulthood. Devices for measuring PA are now more accessible and reasonably priced for researchers than it was in the 1980s.

Future research should strive towards using validated scales when measuring psychological constructs, as this will increase the quality of the analysis of determinants. However, the use of single measures in the NLHB study opened up for the inclusion of several possible determinants related to a wide range of health behaviours. This breadth would not have been possible to include in a questionnaire with follow-up measures over several years if the measures were based on scales with

multiple items. Ongoing research is necessary to validate measures and find measures that are both valid and parsimonious.

The results in this thesis are all based on an outcome measure of LVPA. Future studies should aim at exploring trajectories of MVPA, total PA or physical inactivity, and the relationship between such trajectories, as this will broaden our understanding of the complexities of this health behaviour.

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RESEARCH

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Leisure-time physical activity trajectories from adolescence to adulthood in relation to several activity domains: a 27-year longitudinal study

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Abstract

Background Insufficient physical activity (PA) levels among adolescents and adults make promoting PA a public health priority. Although most people exhibit low or decreasing levels of PA, other groups increase or maintain high levels of activity. These different groups may engage differently in activity domains during their leisure time. This study aimed to identify distinct trajectories of leisure-time vigorous physical activity (LVPA) and to explore whether these trajectories are characterised by differences in four activity domains (participation in organised sports clubs, diversity in leisure-time activities, outdoor recreation, and peer PA) over the life course.

Methods Data were drawn from the Norwegian Longitudinal Health Behaviour Study. The sample of participants ($n = 1103$, 45.5% female) was surveyed 10 times from age 13 years in 1990 to age 40 years in 2017. LVPA trajectories were identified using latent class growth analysis, and mean differences in activity domains were studied using the one-step BCH approach.

Results Four trajectories were identified: active (9%), increasingly active (12%), decreasingly active (25%), and low active (54%). Overall, this analysis showed a declining tendency in LVPA from age 13 to 40 years except for the increasingly active trajectory. Belonging to a trajectory with a higher LVPA level was related to higher mean levels of the included activity domains. Compared with those in the increasing trajectory, people belonging to the decreasing trajectory reported higher mean participation levels in and age at becoming a member of sports clubs, diversity in leisure-time activities, and best friend's activity level during adolescence. However, in young adulthood, people in the increasingly active trajectory reported significantly higher mean levels for the same variables.

Conclusions The development of LVPA from adolescence to adulthood is heterogeneous, suggesting the need for targeted health promotion initiatives. The largest trajectory group included more than 50 percent and was characterized by low levels of LVPA, less engagement in PA domains and fewer active friends. There seems to be little carry-over effect of engagement in organised sports in adolescence regarding level of LVPA later in life. Changes in social surroundings throughout the life span, such as having friends who are more or less engaged in PA, may assist or hinder health enhancing engagement in LVPA.

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Keywords Physical activity, Activity domains, Organised sports, Outdoor recreation, Diversity in leisure-time activities, Peers, Latent class growth analysis, Longitudinal, Adolescence, Adulthood

Background

Physical activity (PA) is well established as a predictor of lifetime health and is essential to the inclusion of health promotion in global health policies and local interventions. Nevertheless, global estimates show that 27.5% of adults [1] and 81% of adolescents [2] do not meet the global recommendations for aerobic exercise, which is at least 150–300 min of moderate-to-vigorous intensity, or at least 75–150 min of vigorous intensity, or a combination of those throughout the week [3]. As pointed out by the recommendations, there seems to be an additional health benefit related to vigorous physical activity, and it has been shown that for the same amount of total PA, higher proportions of PA with vigorous intensity are related to lower mortality [4]. Research related to the mechanisms that promote lifelong PA and decrease inactivity is needed, especially research based on longitudinal data. Longitudinal data allow researchers to examine the life-course patterns of PA over time and across various life events and transitions [5].

To understand further these changes over time and differences between individuals, four approaches have been suggested by Telama [6]: the carry-over value hypothesis, ability and readiness hypothesis, habit-formation hypothesis, and self-selection hypothesis. The carry-over value hypothesis suggests that adults continue to engage in activities they participated in at a young age. The ability and readiness hypothesis suggests that earlier experience and the basic skills connected to this experience contribute to the maintenance of or re-engagement in PA despite participation in different types of activity. The habit-formation hypothesis suggests that behaviour is repeated because it is a habit and that this behaviour is based not only on planned behaviour but is automatic and performed with less awareness. The self-selection hypothesis acknowledges a hereditary disposition to fitness and motor performance in some people, which makes them engage in PA more often in adolescence and adulthood. These hypotheses can be used individually to explain the possible paths of lifelong patterns of PA or they can be applied in a cumulative way through the combination of more than one hypothesis to explain the establishment of an active lifestyle.

A growing body of research has used finite mixture modelling to investigate the development of PA from a life-course perspective. The literature was recently summarised in a systematic review [7]. The number of previous studies looking at the development of PA

from childhood or adolescence to adulthood is limited, and only four studies, based on only two different data materials, both population-based studies from Finland, were identified in the systematic review. These studies identified three or five latent leisure-time PA trajectories and that the most significant proportion of people follow a stable moderate or persistently low level of PA. One study identified two additional trajectories in addition to the three prevalent trajectories (steady high, moderate, or low level of leisure-time PA) that comprised an increasingly active or a decreasingly active trajectory [8].

Emerging research interest in the domains related to PA (i.e., the context in which PA occurs) has also contributed to the knowledge about lifelong engagement in leisure-time PA [9]. Diverse patterns of engagement in PA, both organised and non-organised, in team sports or individual sports, and in a wide variety of activities during adolescence are related to the activity level in adulthood (e.g., [10–15]).

Organised sport provides structures for social interaction and skill development, which are thought to contribute to the development of lifelong PA by establishing habits, abilities, and continued participation. A previous study [16] indicated that participation in sports clubs is associated with a sustained or increased PA pattern and, correspondingly, drop out from organised sport with a decrease in PA from a high level. Kjønniksen and colleagues [12] found that diversity in leisure-time activities (the number of activities participated in) at age 15 years was more strongly related to later activity level at age 23 years than was engagement in specific activities. Earlier experiences with PA and sports make it easy to maintain or re-engage in PA, especially if the newer form of PA differs from the earlier activity [6]. Previous research also indicates that broad and varied experiences during adolescence affect PA habits later in life [11], a finding that is consistent with the ability and readiness hypothesis [6].

Another domain related to PA, and possibly relevant to the Nordic context, is the concept of nature-related outdoor recreation, *friluftsliv*, which is considered a core social and cultural value in Norway [17]. Different forms of outdoor activities may support PA throughout the entire life course. Participation in outdoor PA influences positive attitudes towards PA and contributes to positive activity habits [18]. PA during childhood and adolescence is usually performed with peers, and peers

appear to influence the individual's PA level significantly through behavioural modelling, peer pressure, group norms, and co-participation [19]. When entering adulthood, friends and partners may act as critical agents for activity and inactivity.

There is an evidence gap in the research literature needed to develop a more nuanced understanding of PA development from adolescence into adulthood [7, 9]. This study aimed to identify distinct trajectories of leisure-time vigorous physical activity (LVPA) and to explore whether these trajectories are characterised by differences related to activity domains over the life course. The activity domains included were participation in organised sports, diversity in leisure-time activities, outdoor recreation, and active peers.

Methods

Study sample

Data were drawn from the Norwegian Longitudinal Health Behaviour Study. The study involved participants from 22 randomly selected schools in Hordaland in Western Norway. The sample was geographically limited to this region, which allowed the researchers to maintain close contact with the participants at the beginning of the project to establish a good foundation for this cohort study. A total of 924 students (414 girls, 44.8%) participated in the first survey in 1990. This was 78% of the initial sample of 1195 students, and the average age was 13.3 years. During the two subsequent data collections in school, any new student in any randomly selected school was invited to participate. This meant that a total of 1105 people participated in the survey at least once over the 27 years (89% of the total invited sample of 1242). Written consent was given by parents before participation in the survey. Participants were surveyed 10 times (1990, 1991, 1992, 1993, 1995, 1996, 1998, 2000, 2007, and 2017). For the first three times, the survey was conducted during school hours and the students completed the self-completed questionnaires in class. After that, the questionnaire was distributed by post. Participants were also given an option to respond online for the last two surveys. The questionnaire was distributed during October, with greater variation in time of completion when the survey was sent by post. More information about the sample is found in Additional file 1.

Of the total sample of 1105 participants, only participants having at least one measure of LVPA over the 10 measurement points were included in the analyses, which gave a sample of 1103 participants (45.5% female).

Outcome measure

The outcome measure was LVPA. To assess the participants' level of LVPA, a previously used item from The

Health Behaviour in School-aged Children (HBSC) Study: WHO Collaborative Cross-national Study was included in the questionnaire [20]. The question reads, "Outside school hours, how often do you do sports or exercise to the extent that you become out of breath or sweat?" The following response categories are offered (coding in parenthesis): Every day (7), 4–6 times a week (5), 2–3 times a week (2.5), Once a week (1), Once a month (0.25), Less than once a month (0), and Never (0). In 1993, the first part of the question was changed to "Outside school hours/work". This question was included at all 10 measurement points and has previously been identified as having acceptable to good reliability in an Australian sample [21] and overall good reliability in a Norwegian sample aged 13–18 years [22]. Validity has been found to be fair when correlated with maximal oxygen uptake, especially among girls [22].

Auxiliary variables

Membership in sports clubs The participants' membership status in organised sports was assessed using the question, "Are you a member of a sports club or sports association?" The following response categories were offered: Yes (1), No, but I have been a member before (0), and No, I have never been a member of a sports club (0). This item was included eight times and was excluded at ages 19 and 21 years.

Age at becoming a member of a sports club The participants were asked retrospectively four times from 1990–1993 the question, "When did you become a member of a sports club?". The response categories were I have never been a member of a sports club or sports association (0) and I became a member when I was about years old, with response options of 1–13, 14, 15 or 16 years. Data from these four measurements were recoded into one where the most initial response was preferred.

Diversity in leisure-time activities A list of alternative types of sport or exercise was provided to respondents at the ages of 15 years (33 alternatives), 23 years (33 alternatives, exercise in a fitness centre was added and orienteering was removed), and 40 years (20 alternatives). See complete list of all activities in Additional file 2. Participants recorded the frequency level for all activities using four response categories: Several times a week, Once a week, Less than once a week, and Never. A count variable was computed to measure diversity in leisure-time activities. Performance of a sport or exercise at any frequency was counted in.

Outdoor recreation The questions about outdoor recreational activity were, “How often do you usually do outdoor activity in summer? Outdoor recreation in summer can include hiking, swimming, cycling, or fishing” and “How often do you usually do outdoor activity in winter? Outdoor recreation in winter can include hiking, fishing or cross-country skiing”. The following response categories were offered: Four times a week or more often (4), 2–3 times a week (3), Once a week (2), Less than once a week (1), and Never (0). These items were included at ages 13, 14, 15, 16, 23, 30, and 40 years.

Active friends Peer PA was assessed using two questionnaire items. The first related to the number of friends participating in sports and included the question, “How many of your friends do sports or exercise?”. The response categories were Almost all (4), More than half (3), About half (2), Less than half (1), and None (0). This item was measured at ages 13, 15, and 18 years.

The second peer item related to the level of sports and exercise performed by the participant’s best friend and read, “Does your best friend do sports and exercise?”. The responses options were Four times a week or more (4), 2–3 times a week (3), Once a week (2), Less than once a week (1), Never (0), and I do not have a best friend (missing). This item was measured at ages 13, 15, and 23 years.

Gender (binary, measured at baseline), having children (yes/no, measured at ages 21, 23, 30 and 40 years), income (gross income in intervals of 100 000 NOK, measured at ages 23, 30 and 40 years), and body mass index (BMI, measured at ages 15, 23 and 40 years), which was calculated based on self-reported height and weight, were included to describe the characteristics of the different trajectory classes because previous research has found them to be related to the development of lifetime PA [7, 8, 16, 23–28].

Statistical analysis

The data were managed, and descriptive statistics were calculated using IBM SPSS (version 27.0). The data were converted to Mplus (version 8.7 [29]) for the latent class growth analysis (LCGA). The level of statistical significance was 0.05.

Prior to the LCGA, the data on LVPA from all 10 measurement points were modelled in a latent growth model to explore what number of growth parameters suited the data best. Three models were tested, with two (intercept and slope factor), three (intercept, slope, and quadratic slope factor) and four (intercept, slope, quadratic, and cubic slope factor) growth parameters. The

best fit, determined by the highest comparative fit index (CFI=0.911) and the lowest root mean square error of approximation (RMSEA=0.05) was obtained when the model included four growth parameters. The LCGA was then fitted using the same growth parameters.

Latent class growth analysis

Trajectories for LVPA were identified using LCGA, a type of group-based trajectory model, which makes it possible to identify latent classes of individuals based on their joint growth trajectories over time [30]. The LVPA variable was treated as continuous in the analysis.

Missing data were assumed to be missing at random (MAR) and addressed using full information maximum likelihood estimation (FIML). The model parameters were estimated using the maximum likelihood estimator with robust standard errors (MLR). The number of classes was determined by testing the model fit for two, three, four, five, six, and seven latent trajectory classes.

Akaike information criterion (AIC), Bayesian information criterion (BIC), entropy, average posterior probability > 0.70 for within-group membership, the Vuong–Lo–Mendell–Rubin test (VLMR), and the bootstrap likelihood ratio test (BLRT) were used to assess the fit and interpretability of the model and number of latent trajectory classes [31].

When assessing the class enumeration, we did not find that the AIC and BIC values reached a low point and started to increase. The VLMR test was significant only for the two-class and four-class models ($p < 0.05$). However, the proposed more reliable BLRT was significant for all models. The enumeration was therefore based on entropy and the posterior probability of class membership. Theoretical and empiric support for the four-class solution was also used [31]. The qualitative assessment of the three-class model and five-class model vs the four-class model supported the decision because the three-class solution provided fewer nuances and the five-class solution had two similar and (almost) parallel classes. Figures showing plots of the two- to seven-class models are presented in Additional file 3.

Distal outcome model using the Block–Croon–Hagenaars (BCH) approach

The mean differences in the above-mentioned variables related to activity domains (e.g., membership in sports clubs, diversity in leisure-time activity, peer PA) measured in adolescence, young adulthood, and adulthood were studied across the trajectory classes. To do this, we used the one-step automatic BCH approach. Using this approach to estimate a distal outcome model allowed us to avoid shift of the latent class trajectories so that they were no longer measured only by the LVPA

indicator. Instead, the BCH method avoids a shift in the latent classes (i.e., LVPA trajectories) by using a weighted multiple group analysis in the final stage [32]. In the BCH approach, the auxiliary variables are treated as continuous.

Quality assessment

The Guidelines for Reporting on Latent Trajectory Studies (GRoLTS) [31] checklist was used to ensure the quality of the analysis (see Additional file 4).

Results

Drop out analysis

Drop out analysis were undertaken by comparing baseline values of LVPA, membership in sports club, age at becoming a member of a sport club, outdoor recreation, number of active friends and best friend's activity level to examine whether there was a difference between those who dropped out of the study before age 40 and the 455 respondents who did not. Independent sample t-tests showed no statistically significant differences between these two groups ($p > 0.05$).

Participants and descriptive statistics

Among the total sample, 17% of the participants completed all 10 repeated measurements of LVPA; 15% completed nine measurements, 11% eight, 9% seven, 10% six, 9% five, 11% four, 10% three, 5% two, and 4% one. Table 1 shows the descriptive statistics for all included variables at all 10 measurement points from 1990 to 2017.

LVPA trajectories

Four LVPA trajectories were identified from adolescence to adulthood (Fig. 1). Based on their development, the trajectories were named (ranked from smallest to largest and with the percentage given in parentheses): active (9%), increasingly active (12%), decreasingly active (25%), and low active (54%). The final number of trajectories was selected based on the described fit statistics (Table 2).

The active and decreasingly active trajectories started with the highest LVPA level at the baseline. From here, the active trajectory continued to exhibit higher levels of LVPA than the three other trajectories. The decreasingly active trajectory showed a continuous decrease in activity level from adolescence to young adulthood but exhibited a more stable pattern after age 23 years. The low active trajectory had the lowest mean LVPA at age 13 years and showed a decreasing level of LVPA until the age of 18 years. From here, this trajectory continued at about the same low level until the age of 40 years. The increasing trajectory started with about the same estimated mean LVPA level as the low active trajectory. However, it ended at about the same LVPA level as the

active trajectory at age 40 years and was the only trajectory in which the mean LVPA level increased from age 13 to age 40 years.

Characteristics related to activity domains across the LVPA trajectories

The mean and standard error of all included auxiliary variables across all four trajectories and indications of significant differences between each trajectory are shown in Table 3. The development within the four trajectories is illustrated in Fig. 2.

Organised sports

At the baseline, the active and decreasingly active trajectories showed significantly higher membership levels in organised sports clubs compared with the other two trajectories ($p < 0.01$). From age 13 to 30 years, all trajectories showed a decrease in membership. However, the level of membership in sports clubs increased in the increasingly active trajectory from 0.67 at age 13 years to 0.76 at age 14 years and then decreased as for the other trajectory classes. From age 30 to 40 years, the mean level of membership in sports clubs increased among all four trajectories.

The active and low active trajectories differed significantly at all measurement points ($p < 0.05$). The decreasingly and increasingly active trajectories differed significantly ($p < 0.05$) at ages 13 and 14 years, when the decreasingly active trajectory showed higher participation levels. These trajectories did not differ at ages 15 to 18 years, but at age 23 years, the level of membership in sports clubs decreased more in the decreasingly active trajectory, which made the level in the increasingly active trajectory significantly higher ($p < 0.01$). At age 40 years, the membership level in organised sports was significantly higher in the active and increasingly active trajectories compared with the low active trajectory ($p < 0.05$).

Those in the increasingly active trajectory reported the highest mean age at first participation in organised sports. However, the number of times reported being a member was not significantly lower than the active and the decreasingly active trajectories, whose mean age when becoming a member was younger.

Diversity in leisure-time activities

At age 15 years, the mean level of self-reported diversity in leisure-time activities was significantly higher in the active and decreasingly active trajectories than in the low active and increasingly active trajectories ($p < 0.05$). At age 30 years, the active and increasingly active trajectories exhibited greater diversity than the low active and decreasingly active trajectories. From the age of 30 to 40 years, diversity decreased in all trajectories, and

Table 1 Descriptive statistics of included variables by measurement point

Year	1990	1991	1992	1993	1995	1996	1998	2000	2007	2017
<i>Respondent age</i>	13	14	15	16	18	19	21	23	30	40
<i>N</i>	924	958	936	789	779	643	634	630	536	455
<i>Coding of time in LCGA</i>	-10	-9	-8	-7	-5	-4	-2	0	7	17
<i>LVPA (0–7)</i>										
n	912	952	945	708	777	639	583	628	533	447
Mean	3.18	3.11	3.00	2.55	2.24	2.11	2.02	1.88	1.70	1.99
S.E	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.07	0.08
<i>Membership in sports clubs (No [0], Yes [1])</i>										
n	913	953	940	708	776			628	533	447
Percentage member	65.4	62.4	58.5	52.2	38.8			26.8	23.1	30.5
<i>Diversity in leisure-time activities</i>										
n			927					627		452
Mean			13.57					9.02		7.57
S.E			0.21					0.18		0.16
<i>Outdoor recreation, summer (0–4)</i>										
n	917	949	946	703				628	533	446
mean	3.30	3.12	3.30	2.99				2.84	2.92	3.01
S.E	0.03	0.03	0.03	0.04				0.04	0.04	0.04
<i>Outdoor recreation, winter (0–4)</i>										
n	915	949	945	704				628	534	443
mean	2.94	2.55	2.55	2.23				2.03	2.23	2.32
S.E.	0.03	0.03	0.04	0.04				0.04	0.04	0.05
<i>Number of active friends (0–4)</i>										
n	904		934		772					
Mean	3.16		2.75		2.15					
S.E	0.04		0.04		0.05					
<i>Best friend's activity level (0–4)</i>										
n	878		934					626		
Mean	2.65		2.58					1.93		
S.E	0.04		0.04					0.05		
<i>Gender (Boy [0], Girl [1])</i>										
n ^a	1103									
Percentage of girls	45.6									
<i>BMI</i>										
n			886					606		443
Mean			20.18					23.28		25.52
S.E			0.08					0.15		0.18
<i>Having children (No [0], Yes [1])</i>										
n							585	628	536	449
Percentage having children							7.0	16.4	55.0	85.3
<i>Income (2000: 1–6; 2007: 1–8; 2017: 1–10)</i>										
n								626	534	446
Mean								1.66	3.78	6.45
S.E								0.04	0.07	0.10

The range for the measure of diversity in leisure-time activity was in 1992 0 to 33; in 2000 0–27; and in 2017 0–20. The range for the measure of BMI was in 1992 13.72–33.91; in 2000 14.69–53.98; in 2017 18.36–41.40

LCGA Latent class growth analysis, LVPA Leisure-time vigorous physical activity, BMI Body mass index

^aThe n is based on data from all measurement points

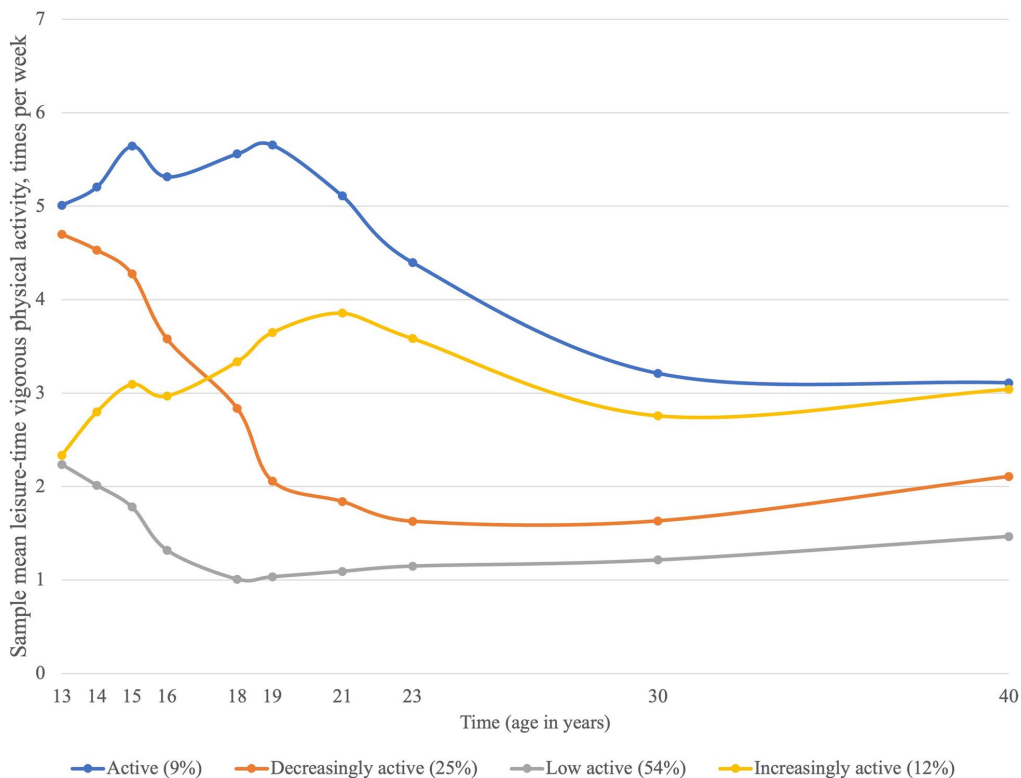


Fig. 1 Leisure-time vigorous physical activity trajectories (n = 1103)

Table 2 Latent Class Growth Analysis (LCGA) based on the total sample

No. of classes	AIC	BIC	BLRT	VLMR	Entropy	Average Latent Class Probabilities for Most Likely Latent Class Membership (%)	Sample Size Per Class Based on Most Likely Class Membership	The Number of Random Start Values and Final Iterations
1	29,901.46	29,971.54	--	--	--	100	1103	200, 20
2	28,520.17	28,615.28	<i>p</i> < .05	<i>p</i> < .05	0.773	92/94	324/779	200, 20
3	28,248.55	28,368.69	<i>p</i> < .05	<i>p</i> = .07	0.690	89/77/85	612/342/149	200, 20
4	28,090.97	28,236.14	<i>p</i> < .05	<i>p</i> < .05	0.703	84/78/87/75	102/276/597/128	200, 20
5	27,997.88	28,168.08	<i>p</i> < .05	<i>p</i> = .20	0.664	77/72/71/82/87	122/292/169/471/49	200, 20
6	27,928.51	28,123.74	<i>p</i> < .05	<i>p</i> = .61	0.664	81/85/70/71/72/86	483/46/268/121/141/44	200, 20
7	27,871.38	28,091.64	<i>p</i> < .05	<i>p</i> = .11	0.653	87/84/78/74/72/71/62	41/34/432/166/62/190/178	200, 20

AIC Akaike information criterion, BIC Bayesian information criterion, BLRT Bootstrap likelihood ratio test, VLMR Vuong-Lo-Mendell-Rubin test
 The class solution considered optimal is presented in bold

the mean diversity in leisure-time activities did not differ significantly between the active, decreasingly active, and increasingly active trajectories. However, all three differed significantly from the low active trajectory.

Outdoor recreation

People in the low active trajectory reported significantly lower (*p* < 0.05) mean levels of outdoor recreation than those following the active trajectory at all measurement

Table 3 Distal outcome model using the Block-Croon-Hagenaars (BCH) approach for included activity domains, demographic and socioeconomic variables

	P													
	Active ^a			Decreasingly active ^b			Low active ^c			Increasingly active ^d				
	Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E	a vs. b	a vs. c	a vs. d	b vs. c	b vs. d	c vs. d
<i>Membership in sports clubs</i>														
Age 13	0.90	0.04	0.91	0.03	0.46	0.03	0.66	0.06	0.773	<0.001	0.003	<0.001	0.001	0.004
Age 14	0.87	0.05	0.92	0.03	0.37	0.03	0.76	0.06	0.362	<0.001	0.158	<0.001	0.018	<0.001
Age 15	0.88	0.05	0.84	0.04	0.35	0.03	0.70	0.06	0.540	<0.001	0.022	<0.001	0.057	<0.001
Age 16	0.88	0.05	0.78	0.04	0.25	0.03	0.65	0.07	0.190	<0.001	0.012	<0.001	0.137	<0.001
Age 18	0.84	0.06	0.62	0.05	0.12	0.02	0.58	0.07	0.005	<0.001	0.003	<0.001	0.649	<0.001
Age 23	0.67	0.08	0.25	0.05	0.11	0.02	0.57	0.07	<0.001	<0.001	0.386	0.026	0.002	<0.001
Age 30	0.45	0.10	0.23	0.05	0.14	0.03	0.39	0.07	0.061	0.002	0.610	0.130	0.117	0.004
Age 40	0.58	0.10	0.31	0.06	0.21	0.03	0.44	0.09	0.030	<0.001	0.323	0.177	0.232	0.016
Age when first member	7.20	0.28	7.62	0.19	8.44	0.14	8.54	0.34	0.253	<0.001	0.004	0.001	0.029	0.798
Number of times reported member	4.18	0.25	3.66	0.15	1.41	0.09	3.66	0.25	0.098	<0.001	0.153	<0.001	1.000	<0.001
<i>Diversity in physical activities</i>														
Age 15	15.61	0.80	16.16	0.53	11.77	0.36	13.41	0.71	0.592	<0.001	0.049	<0.001	0.004	0.052
Age 23	12.52	0.65	9.26	0.49	7.42	0.28	11.92	0.56	<0.001	<0.001	0.508	0.002	0.001	<0.001
Age 40	9.62	0.64	8.35	0.38	6.50	0.26	8.71	0.57	0.109	<0.001	0.306	<0.001	0.623	0.001
<i>Outdoor recreation</i>														
Age 13, summer	3.40	0.12	3.39	0.07	3.20	0.05	3.40	0.11	0.922	0.110	0.981	0.040	0.939	0.110
Age 13, winter	3.07	0.12	3.16	0.08	2.8	0.05	2.87	0.12	0.585	0.037	0.243	<0.001	0.057	0.640
Age 14, summer	3.28	0.12	3.16	0.08	2.98	0.06	3.39	0.10	0.450	0.020	0.473	0.084	0.099	0.001
Age 14, winter	2.89	0.13	2.75	0.08	2.33	0.06	2.70	0.12	0.384	<0.001	0.306	<0.001	0.785	0.006
Age 15, summer	3.50	0.9	3.42	0.07	3.16	0.05	3.38	0.11	0.522	0.001	0.427	0.008	0.801	0.079
Age 15, winter	2.99	0.13	2.82	0.09	2.29	0.06	2.65	0.13	0.301	<0.001	0.065	<0.001	0.304	0.014
Age 16, summer	3.34	0.13	3.09	0.09	2.80	0.07	3.18	0.12	0.127	<0.001	0.358	0.016	0.582	0.009
Age 16, winter	2.76	0.16	2.51	0.09	1.89	0.07	2.42	0.13	0.202	<0.001	0.105	<0.001	0.578	0.001
Age 23, summer	3.43	0.14	2.92	0.10	2.58	0.07	3.23	0.12	0.007	<0.001	0.317	0.008	0.073	<0.001
Age 23, winter	2.95	0.17	1.98	0.12	1.71	0.06	2.61	0.14	<0.001	<0.001	0.145	0.054	0.002	<0.001
Age 30, summer	3.27	0.16	2.81	0.12	2.76	0.07	3.44	0.10	0.027	0.002	0.394	0.689	<0.001	<0.001
Age 30, winter	2.81	0.20	2.12	0.12	1.94	0.07	2.98	0.13	0.006	<0.001	0.506	0.216	<0.001	<0.001
Age 40, summer	3.35	0.14	3.00	0.10	2.75	0.08	3.63	0.11	0.056	<0.001	0.127	0.069	<0.001	<0.001
Age 40, winter	2.92	0.15	2.35	0.12	2.05	0.08	2.75	0.16	0.006	<0.001	0.447	0.047	0.060	<0.001
<i>Number of active friends</i>														
Age 13	3.60	0.10	3.57	0.07	2.79	0.07	3.31	0.14	0.796	<0.001	0.099	<0.001	0.117	0.002
Age 15	3.43	0.12	3.27	0.10	2.26	0.07	2.95	0.15	0.350	<0.001	0.015	<0.001	0.090	<0.001
Age 18	3.06	0.15	2.40	0.13	1.68	0.07	2.60	0.17	0.002	<0.001	0.053	<0.001	0.382	<0.001

Table 3 (continued)

	Active ^a		Decreasingly active ^b		Low active ^c		Increasingly active ^d		P					
	Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E	a vs. b	a vs. c	a vs. d	b vs. c	b vs. d	c vs. d
Best friend's activity level														
Age 13	3.16	0.13	3.12	0.09	2.39	0.09	2.26	0.14	0.848	<0.001	<0.001	<0.001	<0.001	0.434
Age 15	3.49	0.11	2.95	0.10	2.20	0.10	2.53	0.14	<0.001	<0.001	<0.001	<0.001	0.021	0.048
Age 23	2.78	0.23	1.86	0.15	1.54	0.15	2.78	0.18	0.002	<0.001	0.990	0.071	<0.001	<0.001
Gender	0.22	0.05	0.30	0.04	0.56	0.04	0.55	0.06	0.206	<0.001	<0.001	<0.001	0.002	0.939
Body mass index														
Age 15	20.11	0.31	20.16	0.18	20.18	0.18	20.29	0.27	0.903	0.849	0.686	0.952	0.729	0.733
Age 23	23.79	0.45	23.29	0.37	23.13	0.37	23.46	0.50	0.422	0.193	0.640	0.752	0.795	0.581
Age 40	24.39	0.62	25.88	0.40	25.62	0.40	25.30	0.75	0.059	0.069	0.371	0.638	0.532	0.711
Having children														
Age 21	0.02	0.03	0.05	0.03	0.11	0.03	0.01	0.02	0.380	0.003	0.947	0.098	0.330	0.003
Age 23	0.10	0.05	0.19	0.05	0.19	0.05	0.08	0.04	0.265	0.113	0.740	0.905	0.123	0.037
Age 30	0.43	0.10	0.53	0.06	0.61	0.06	0.47	0.08	0.391	0.069	0.728	0.272	0.574	0.122
Age 40	0.87	0.07	0.96	0.03	0.81	0.03	0.79	0.07	0.246	0.457	0.445	0.002	0.036	0.776
Income														
Age 23	1.64	0.15	1.75	0.11	1.68	0.11	1.48	0.11	0.594	0.784	0.402	0.626	0.118	0.115
Age 30	5.00	0.35	3.86	0.18	3.62	0.18	3.53	0.22	0.008	<0.001	0.001	0.276	0.283	0.734
Age 40	7.78	0.43	6.90	0.25	5.82	0.25	6.86	0.41	0.101	<0.001	0.139	0.001	0.930	0.027

Statistically significant (p<0.05) results are marked with bold font

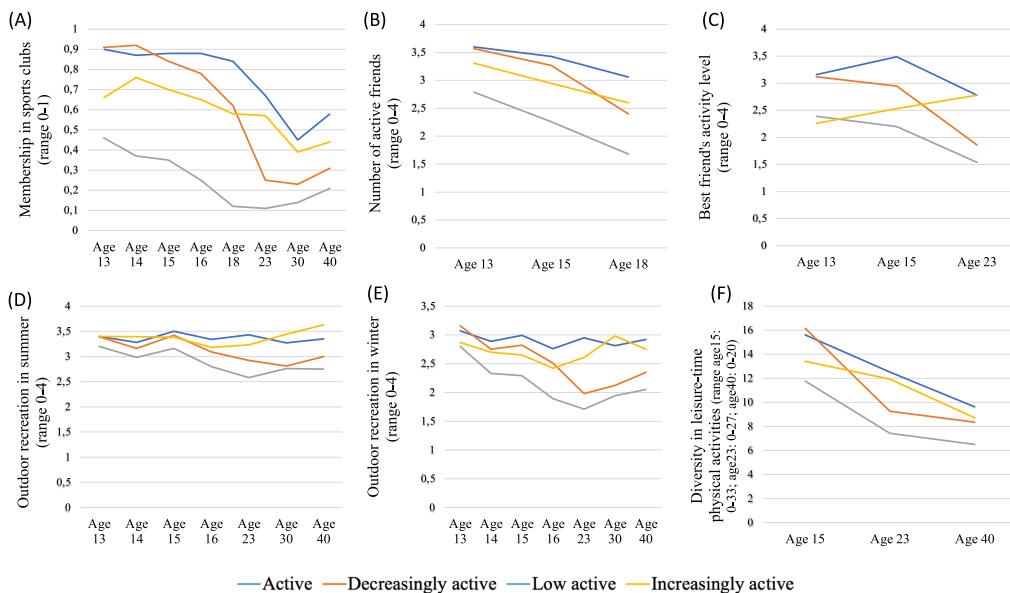


Fig. 2 Mean values for activity domains measured multiple times (A = membership in organised sports clubs; B = number of active friends; C = best friend's activity level; D = Outdoor recreation in summer; E = Outdoor recreation in winter; F = diversity in leisure-time activities) across the leisure-time vigorous physical activity trajectories

points, except during summer at age 13 years. The mean level also differed significantly between the low active and decreasingly active trajectory at most of the measurement points during adolescence. However, from age 23 years, the mean levels did not differ between these two trajectories except for outdoor recreation during the winter at age 40 years, when the low active class reported significantly lower mean levels. The low active trajectory class reported significantly lower outdoor recreation levels than those in the increasingly active trajectory class except at age 13 and in winter at age 15 years.

At age 23, we also found significantly lower ($p < 0.05$) mean levels of outdoor recreation during both summer and winter for the decreasingly active trajectory than for the active trajectory, and during winter compared to the increasingly active trajectory. At age 30, both the active and the increasingly active trajectories showed significantly higher ($p < 0.05$) mean levels of outdoor recreation than the decreasingly active trajectory. At age 40 years, there was a significant ($p < 0.05$) lower mean level of outdoor recreation during winter in the decreasingly active trajectory compared with the active trajectory.

Active peers

The number of active friends decreased in all classes from age 13 to 23 years. The number of active friends was

significantly higher ($p < 0.01$) at all three measurement points in the active, decreasingly active, and increasingly active trajectories than in the low active trajectory. At age 15 years, the difference was also significant ($p < 0.05$) between the active and increasingly active trajectories. At age 18 years, the active and the decreasingly active trajectories differed significantly ($p < 0.01$).

At ages 13 and 15 years, those in the active trajectory reported significantly higher ($p < 0.001$) mean level of best friend's PA compared with the low active and increasingly active trajectories. At age 13 years, the reported level of best friend's PA differed significantly ($p < 0.05$) between the low active and increasingly active trajectories compared with the decreasingly active trajectory. At age 15 years, best friend's PA differed significantly ($p < 0.05$) between all trajectories. However, at age 23 years, the active and increasingly active trajectories reported the same mean best friend's PA, which was significantly higher ($p < 0.01$) than that reported for the other two trajectories.

Related demographic variables

Mean BMI did not differ significantly between the four trajectories. Having children was more frequently reported in the low active trajectory at age 21 years, when this frequency differed significantly ($p < 0.01$) from those of the active and increasingly active trajectories. At

age 23 years, the frequency of having children differed ($p < 0.05$) only between the low active and increasingly active trajectories. At age 40 years, the frequency of having children differed significantly ($p < 0.05$) between the decreasingly active and the low active and increasingly active trajectories. Income at age 23 years did not differ significantly between the four trajectories, although the mean income at age 30 years was significantly higher ($p < 0.01$) in the active trajectory than in the other trajectories. At age 40 years, the low active trajectory had a significantly lower ($p < 0.05$) mean income than the other trajectories.

Discussion

In this study, we aimed to identify developmental patterns of LVPA in a Norwegian sample with a follow-up of 27 years. We identified four LVPA trajectory classes from early adolescence to middle adulthood; these results partly support the findings of two cohort studies from Finland [7, 33].

The largest trajectory identified was the low active trajectory, which included slightly more than half of the sample (54%). Previous studies have also found a proportionally larger trajectory class with a persistently low PA level [8, 33–35]. Those following the low active trajectory reported the lowest mean LVPA level at all measurement points and showed considerable stability in their development. These results support the findings of a systematic review that showed that the low active trajectories appear to be more stable than more active trajectories [7] and a previous study showing that inactivity tracks better than activity [6].

The active trajectory appears at the other end of the spectrum and had the highest average level of LVPA at all measurement points, although it represented only 9% of the sample. A larger decreasingly active trajectory (25% of the sample) was identified at about the same high level of weekly LVPA as the active trajectory at age 13 years. From the age of 13 to 23 years, the weekly LVPA level decreased markedly in this trajectory. However, the LVPA level did not decline to the level of the low active trajectory, a finding that is consistent with previous research [7]. It is possible that high LVPA levels during adolescence may have contributed to a later decline in PA and prevented an earlier onset of lower activity. An increasingly active trajectory, representing 12% of the sample, was identified that exhibited a slightly different development from the other trajectory classes because the weekly LVPA increased from age 13 to 40 years.

Attention has focused on establishing habits when promoting lifelong engagement in PA. As indicated in the habit-formation hypothesis [6], repetition and routine are needed to form lasting habits. People in the active trajectory class are highly engaged in all activity domains from

adolescence to adulthood. This consistency in engagement probably entails repeated PA behaviour over time, which increases the potential for establishing long-lasting PA habits.

The respondents following the decreasing trajectory may be labelled “early bloomers”. They had a high engagement in various PA domains in early adolescence, much like those in the active trajectory. However, their engagement and LVPA level declined from adolescence to young adulthood. The transition from adolescence to early adulthood reflects changes in the types of activities that are available and other critical life transitions such as moving away from home or starting higher education. As indicated in the carry-over value hypothesis, such changes can make continuing PA difficult if the possibility of engaging in the same type of activity as before is reduced [6]. It seems that people in the decreasingly active trajectory continue to engage in various activities during adolescence, which suggests some habitual behaviour but of lower intensity.

The findings of the current study also suggest that the people in the increasing trajectory were “late bloomers”, with a higher LVPA level during young adulthood and adulthood than in adolescence. However, the late onset does not seem to have hindered the positive development of a physically active lifestyle. The increasingly active trajectory was the only trajectory whose activity level continued to increase in young adulthood. The ability and readiness hypothesis suggests that experiences in PA and sports, such as organized sports, and the related basic skills, make it easier to continue with PA or to re-engage after a break. Thus, previous experience is valuable even though the type of activities and domains may differ at a later stage [6], for instance, PA at fitness centres or organised sports clubs for students.

Activity domains in relation to trajectories

Membership in organised sports clubs

The active trajectory was characterised by higher participation in organised sports. However, at age 13 years, almost half the respondents in the low active trajectory also reported membership in organised sports, which suggests that membership alone does not necessarily guarantee higher levels of LVPA among adolescents. Similar results based on objectively measured PA have been reported in a youth sample from Finland [16]. There are several possible reasons why membership in organised sports did not ensure higher levels of LVPA for those in the low active trajectory in our study. One reason is the nature of the measurement used in this study, which did not include the frequency, duration, or intensity of PA related to the respondents' engagement in sports clubs. The respondents may be members of an organised sports

club but may participate seldom or have low engagement. Negative experiences (e.g., low motivation or mastery, conflict with coaches or peers) may also explain why those in the low active trajectory did not continue to participate in organised sports for extended periods, as indicated by the low average frequency of reported club membership. Therefore, their experiences with organised sports may have been too brief to make a lasting impact on their PA during the life course.

Respondents following the decreasingly active trajectory also reported high levels of membership in sports clubs, becoming a member of a sports club at an early age, and being a member at multiple measurement points. However, there did not seem to be a carry-over effect of these prior experiences, as shown by their decreasing activity level from age 13 to 23 years. This might be related to factors outside of sports clubs, such as injury, new interests and priorities, or different experiences with sports clubs or activities. Therefore, it is important to acknowledge that the same activity domain can contribute to both positive and negative experiences, which may influence the development of LVPA over time in different directions.

Active peers

As supported by a previous study [19], peers can affect PA behaviour across, and in addition to, other domains. The peers' activity levels may contribute to an increase or decrease in a person's LVPA level. For example, the periods of adolescence and transition into young adulthood carry multiple opportunities to establish new relationships. We found an increase in the best friend's activity level during the transition from adolescence to young adulthood among those in the increasingly active trajectory but a decrease among those in the decreasingly active trajectory. These findings emphasise the importance of peers to the development of LVPA and highlight how health promotion interventions should consider including peer relationships in initiatives to promote PA [19].

Diversity in leisure-time activities

Consistent with the ability and readiness hypothesis [6], we found that respondents in the trajectories exhibiting a stable engagement in a diversity of leisure-time activities either increased or maintained their relatively high LVPA level. By contrast, respondents in the decreasingly active trajectory showed a greater decrease in diversity in leisure-time activities from adolescence to young adulthood. Engagement in multiple sports and PAs during adolescence may provide an important base for developing motor skills and promoting long-lasting engagement in higher LVPA level later in life. This association has

been shown in longitudinal studies [11, 12, 36]. Continuing to participate in several different sports or activities throughout adolescence and into adulthood may have contributed to the maintenance of a higher LVPA level, even though the number of activities the respondents participated in at age 40 years did not differ between the active, increasingly active, and decreasingly active trajectories.

Outdoor recreation

All trajectories showed relatively high levels of outdoor recreation during both summer and winter during adolescence. Engagement in outdoor recreation is closely linked to cultural characteristics in Norway, and it is common to spend leisure time outdoors, especially during weekends and holidays [12]. We found significant differences indicating that respondents in the low active trajectory engaged less in these activities than the other trajectories. However, our findings do not allow us to determine how outdoor recreation contributed to the LVPA level. By being accessible to all and not requiring membership or special equipment, outdoor recreation may contribute to LVPA throughout the life course more broadly than organised sports or PA at fitness centres. In our study, respondents following the low active trajectory seemed to be less active in outdoor recreation during winter compared with the other trajectories. Outdoor recreation in winter can be challenging in a Nordic country like Norway. Such seasonal changes may be important to consider when planning initiatives to promote activity, at least for outdoor recreation during winter among those in the low active trajectory.

Demographic and socio-economic status across the LVPA trajectories

The active and decreasingly active trajectories were more prevalent among males than females, which is consistent with earlier reports [7, 16, 25]. In contrast to previous research on the relationship between BMI and PA development [23, 26, 27], our study did not find differences in these parameters between the four trajectories. At age 21 years, the low active trajectory was characterised by more respondents having children compared with the two trajectories with the highest LVPA level at that time. Previous research has found that having a child is negatively associated with overall PA [24], that having children increases the odds of belonging to the decreasingly active trajectory [8], and that, among women, having children has a strong negative effect on the number of sports practised [28]. At age 40 years, a large proportion of the respondents reported having children. In Norway, most organised sports clubs rely on parental engagement and voluntary work, which may explain the increase in sports club membership at age 40 years among the respondents in our study. Our findings

of significant differences in income between the active and low active trajectories are consistent with those of studies analysed in a recent systematic review [7] and suggest that mean income is higher in the active trajectory.

Limitations

This study has some limitations. Self-reporting might lead to over- or under-reporting [37]. We used a single item regarding frequency to measure LVPA, which may have oversimplified this phenomenon with many different dimensions, such as type of activity or duration. However, use of this single-item question has been shown to have acceptable reliability and validity [21, 38]. Further validation studies are needed [39], including validation across the life course. Adding a measure of moderate physical activity or sedentary behaviour could have enriched our analysis, however these types of measurements were not available in the data material.

We assessed participation in organised sports using a single item related to sport club membership. Membership does not necessarily indicate active participation, and having more items related to sports participation, such as frequency and level of activity, may have strengthened our analysis. This is also relevant to many of the other items related to activity domains. For example, to assess the diversity in leisure-time activities, we created a sum score based on more detailed information related to the types of activities and frequencies. Excluding this sum score and analysing specific details may have added valuable information about the degree of active participation in different activities across the four trajectories. However, for some activities, the number of respondents was too low, and we would not have been able to include the whole range of different activities in the analyses.

The analyses did not control for any variables, and the differences between the classes on the auxiliary variables may reflect an effect of confounders. We did not assess the strength of the associations or compare them with each other but examined only the different characteristics of the four latent trajectory classes grouped according to LVPA. Lastly, to summarise data, a reduction is sometimes needed. In group-based models, one reduces by approximation and by grouping, and comparing individuals who are not entirely homogenous [30]. Therefore, it is essential to recognise that trajectory group membership is not definite because the LCGA gives only the probability of following a trajectory. Further, our results are not necessarily generalisable to other populations as the studied sample represents a population from western Norway. However, the baseline mean of LVPA at age 13 in this sample (collected in October/November 1990) was almost identical to that of the nationally representative

HBSC study sample of 13-year-olds ($n = 1616$) collected in November 1989, suggesting that the study sample from western Norway at baseline was representative of Norwegian youth in the relevant age group [12]. The main strength of the present study is its longitudinal design and long-time follow-up with many measurement points, relatively large sample size, and comprehensive use of self-reported measures of LVPA and engagement in different activity domains. In addition, using finite mixture modelling of longitudinal data provides new information about the complexity of PA behaviour over that provided by population-based mean levels.

Conclusions

Four life-course trajectories of LVPA were identified in this 27-year longitudinal study in Norway. Primarily, the findings suggest heterogeneity in the development of LVPA across different life periods. Secondly, the largest trajectory group included more than half of the respondents and was characterised by a low LVPA level and low engagement in the four activity domains, calling for increased recruitment into different activity domains for children and adolescents at high risk of falling into this trajectory. Thirdly, engagement in organised sports in adolescence does not seem to have a sustainable carry-over effect on the level of LVPA later in life. For organised sports clubs to contribute to life-long PA, there needs to be more awareness on drop-out and retention. Lastly, those belonging to the more active trajectories reported having more active peers, indicating that the social impact of friends influences the activity level. In the development of PA, changing social surroundings during life may assist or hinder health enhancing engagement in LVPA. This and the heterogeneity in LVPA development from adolescence to adulthood highlights the need for targeted and age group specific health promotion initiatives.

Abbreviations

AIC	Akaike information criterion
BCH	Block-Croon-Hagenaars
BIC	Bayesian information criterion
BLRT	Bootstrap likelihood ratio test
BMI	Body mass index
CFI	Comparative fit index
FIML	Full information maximum likelihood
GROLTS	Guidelines for Reporting on Latent Trajectory Studies
HBSC	The Health Behaviour in School-aged Children (HBSC) Study, WHO Collaborative Cross-national Study
LCGA	Latent class growth analysis
LVPA	Leisure-time vigorous physical activity
MAR	Missing at random
MLR	Maximum likelihood estimator with robust standard error
PA	Physical activity
RMSEA	Root mean square error of approximation
VLMR	Vuong-Lo-Mendell-Rubin test

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12966-023-01430-4>.

Additional file 1. Information about the recruitment and representativeness of the sample, consent, data collection and how missing data was handled.

Additional file 2. Table showing the different types of leisure-time activities that were included in the questionnaire in 1992, 2000 and 2017. These data were used to make the measure of diversity in leisure-time activities.

Additional file 3. The plots for the one- to seven-class solutions for the LCGA are shown. The plots show the sample mean of leisure-time vigorous physical activity (times per week) from age 13 to age 40 (n=1103).

Additional file 4. Completed checklist for guidelines for reporting on latent trajectory studies (GROLTS).

Additional file 5. Completed STROBE checklist.

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Authors' contributions

FKSM, TT and BW prepared the outline for the first draft and created a data analysis plan. FKSM conducted the analysis and prepared the first draft of the manuscript. CF, TT and BW contributed to the interpretation of the results and critically reviewed the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The data and materials used for the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the Data Protection Services at the Norwegian Centre for Research Data and was conducted in full accordance with the ethical principles of the Declaration of Helsinki. Written consent from parents and participants was required prior to participation in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Additional information about the sample

The NLHB study follows the same participants from age 13 in 1990 to age 40 in 2017, in all ten times. See Table 1 below for the number of participants and age at each data collection.

The sample was drawn from 22 randomly selected schools (54 classes), picked systematically from an alphabetical list of all schools in the region. To allow close contact with the participating students in the important early phase of the project the sample was limited geographically to the county of Hordaland on the west coast of Norway. At the first data collection in 1990, nine hundred and twenty-four students participated. This was 77% of the 1195 students who were initially invited to take part. Excluded from this sample were those whose parents did not give their consent for participating or who failed to return the consent form (n=222); those who did not wish to participate (n=46); and those who provided unusable responses (n=3).

Any new student in the included schools in 1991 and 1992 were invited to participate, increasing the total number of students invited by 47, resulting in a total sample of 1242.

Twenty nine of these did not participated in 1990,1991 or 1992, but participated at least once during the data collections between 1993 and 2017.

Table 1. Measurement years, age and total number of participants per measurement year.

	1990	1991	1992	1993	1995	1996	1998	2000	2007	2017
Age	13	14	15	16	18	19	21	23	30	40
N	924	958	963	789	779	643	634	627	536	455

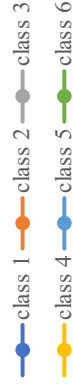
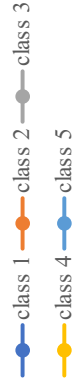
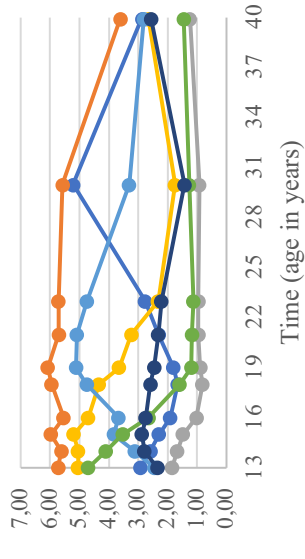
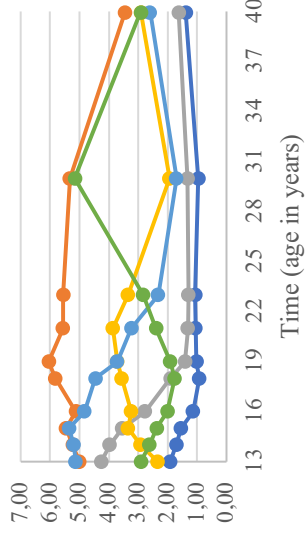
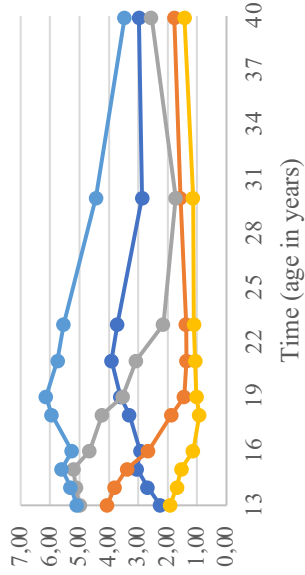
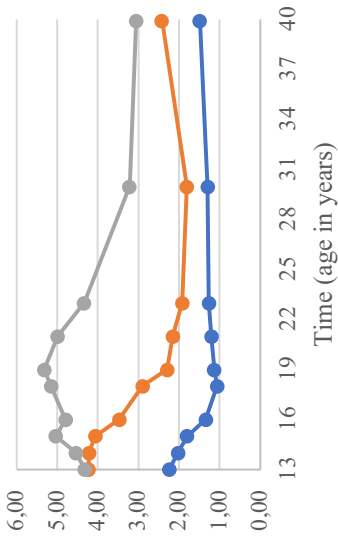
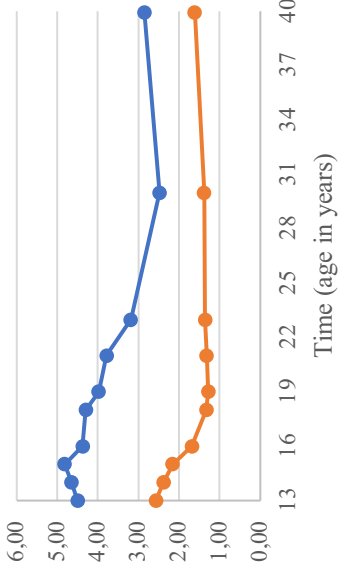
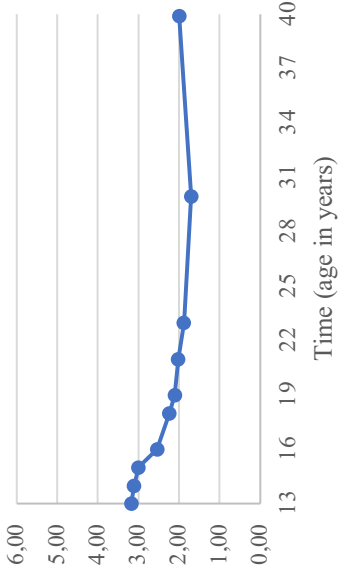
For the present data analysis, participants with at least one measurement of LVPA over the ten measurement points were included. This reduced the included sample to 1103 participants.

Missing data were assumed to be missing at random (MAR) and addressed using full information maximum likelihood estimation (FIML).

<i>Type of leisure-time activity</i>	<i>Included in questionnaire</i>		
	<i>1992</i>	<i>2000</i>	<i>2017</i>
Walking/hiking	x	x	x
Walking fast > 10 minutes	x	x	x
Hard work (house, garden, etc.)	x	x	x
Cycling to school/work/etc. > 10 minutes	x	x	x
Jogging alone	x	x	x
Jogging with others	x	x	x
Aerobics	x	x	x
Dancing	x	x	x
Weight or power lifting	x	x	x
Martial arts	x	x	
Body building	x	x	
Judo, karate	x	x	
Soccer	x	x	x
Basket, volley, handball	x	x	x
Diving	x	x	x
Cycling	x	x	x
Gymnastics	x	x	
Track running	x	x	
Track & field	x	x	
Table tennis	x	x	
Badminton, tennis, squash	x	x	x
Horse riding	x	x	
Archery, golf, bowling	x	x	
Rowing, canoeing	x	x	
Orienteering (in summer)	x		
Windsurfing, sailing (in summer)	x	x	x
Diving (in summer)	x	x	
Jet ski (in summer)	x	x	
Hang-gliding, air sport (in summer)	x	x	
Skating, ice hockey, bandy (in winter)	x	x	x
Downhill, ski jumping (in winter)	x	x	x
Cross-country skiing, biathlon (in winter)	x	x	x
Fitness centre		x	x
Other	x	x	x

Supplement 2,

Plot of the one-, two-, three-, five-, six-, and seven-class solution for the Latent class growth analysis
Sample mean of leisure-time vigorous physical activity, times per week



Additional file 1

Filled out checklist for guidelines for reporting on latent trajectory studies (GRoLTS)*.

	Checklist Item	Reported?
1.	Is the metric of time used in the statistical model reported?	Yes
2.	Is information presented about the mean and variance of time within a wave?	No
3a.	Is the missing data mechanism reported?	Yes
3b.	Is a description provided of what variables are related to attrition/missing data?	No
3c.	Is a description provided of how missing data in the analyses were dealt with?	Yes
4.	Is information about the distribution of the observed variables included?	Yes
5.	Is the software mentioned?	Yes
6a.	Are alternative specifications of within-class heterogeneity considered (e.g., LGCA vs. LGMM) and clearly documented? If not, was sufficient justification provided as to eliminate certain specifications from consideration?	No
6b.	Are alternative specifications of the between-class differences in variance-covariance matrix structure considered and clearly documented? If not, was sufficient justification provided as to eliminate certain specifications from consideration?	No
7.	Are alternative shape/functional forms of the trajectories described?	Yes
8.	If covariates have been used, can analyses still be replicated?	Not used
9.	Is information reported about the number of random start values and final iterations included?	Yes
10.	Are the model comparison (and selection) tools described from a statistical perspective?	Yes
11.	Are the total number of fitted models reported, including a one-class solution?	Yes
12.	Are the number of cases per class reported for each model (absolute sample size, or proportion)?	Yes
13.	If classification of cases in a trajectory is the goal, is entropy reported?	Yes
14a.	Is a plot included with the estimated mean trajectories of the final solution?	Yes
14b.	Are plots included with the estimated mean trajectories for each model?	Yes, sample mean
14c.	Is a plot included of the combination of estimated means of the final model and the observed individual trajectories split out for each latent class?	No
15.	Are characteristics of the final class solution numerically described (i.e., means, SD/SE, n, CI, etc.)?	No
16.	Are the syntax files available (either in the appendix, supplementary materials, or from the authors)?	Yes, from the authors

*Rens van de Schoot, Marit Sijbrandij, Sonja D. Winter, Sarah Depaoli & Jeroen K. Vermunt (2017) The GRoLTS-Checklist: Guidelines for Reporting on Latent Trajectory Studies, Structural Equation Modeling: A Multidisciplinary Journal, 24:3, 451-467, DOI: 10.1080/10705511.2016.1247646

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1	
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2	
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-5	
Objectives	3	State specific objectives, including any prespecified hypotheses	5	
Methods				
Study design	4	Present key elements of study design early in the paper	5	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5	
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	5	See also additional file on sample
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8	
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8	
Bias	9	Describe any efforts to address potential sources of bias	8	
Study size	10	Explain how the study size was arrived at	6	

Continued on next page

1

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-10	
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	8-10	
		(b) Describe any methods used to examine subgroups and interactions		
		(c) Explain how missing data were addressed	9	
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy		
		(e) Describe any sensitivity analyses		
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram		Additional file 3
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders		
		(b) Indicate number of participants with missing data for each variable of interest		Table 1
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)		
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time		
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure		
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures		
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included		n/a
		(b) Report category boundaries when continuous variables were categorized		n/a
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		n/a

Continued on next page

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Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	21-22
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-23
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	24

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

RESEARCH

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Adolescent determinants of life-course leisure-time vigorous physical activity trajectories: a 27-Year longitudinal study

Frida Kathrine Sofie Mathisen^{1*}, Sara Madeleine Kristensen¹, Coral Falco² and Bente Wold¹

Abstract

Background Adolescence is regarded as formative years for building the foundations for life-long health and well-being, and adolescent determinants of physical activity (PA) development is particularly interesting. Novel approaches for the study of PA development, such as group-based trajectory modelling, opens for the possibility of identifying different patterns in the relationship among several known determinants of PA. This study aimed to explore how demographic, psychological and social factors in early adolescence determine membership in four distinct leisure-time vigorous physical activity (LVPA) trajectories from 13 to 40 years.

Methods This study is based on data from the Norwegian Longitudinal Health Behaviour Study, following a cohort born in 1977 from Western Norway. Four trajectories identified using latent class growth analysis, based on self-reported LVPA ($n = 1103$, 45.5% women) measured ten times from age 13 to age 40 and 17 different adolescent determinants, were used in a multivariate multinomial logistic regression.

Results We found that gender (male), VPA intentions the next year and athletic identity associated with belonging to the two trajectories reporting the highest levels of LVPA in adolescence, while VPA intentions in ten years were associated with belonging to the active trajectory compared to the decreasingly active and low active trajectories. Enjoyment increased the odds of belonging to the increasingly and decreasingly active trajectories compared to the low active trajectory. In addition, two of the social determinants, mother's PA and emotional support from father, were associated with belonging to the increasingly active trajectory when compared to the low active trajectory. Higher family income increased the odds of belonging to the increasingly active compared to the decreasingly active trajectory.

Conclusions Both demographic, psychological, and social factors were identified as determinants of LVPA trajectory membership, and the findings support previous research related to the importance of intentions, but also indicate that enjoyment, role modelling and emotional support in PA can be of great importance to LVPA promotion among adolescents.

Keywords Physical activity, Adolescence, Adulthood, Cohort study, Latent class growth analysis, Trajectory, Determinant

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Background

The positive outcomes of physical activity (PA) on mental and physical health are well recognised [1, 2]. However, globally, more than a quarter of all adults are not sufficiently physically active [3], calling for knowledge-based strategies to increase PA. Traditionally, PA has been defined as “any bodily movement produced by skeletal muscles that result in energy expenditure” (4, p. 126). This definition sets PA as a mechanical act. New perspectives on PA, acknowledging the complex nature of PA and the need for ecological perspectives, call for a new definition where PA is defined as involving “people moving, acting and performing within cultural specific spaces and contexts, and influenced by a unique array of interests, emotions, ideas, instructions and relationships” (5, p. 5). This definition emphasises the importance of the context and different modes of PA. Leisure-time is the mode, or domain, of PA contributing most to the total PA in high-income countries [6]. Further, PA can be defined in relation to frequency, duration, type, and intensity. For example, activity with an intensity that makes one sweat or get out of breath is often defined as vigorous physical activity (VPA). PA at this level of intensity is thought to have specific benefits related to all-cause mortality [7].

Identifying leisure-time vigorous physical activity (LVPA) trajectories at different phases in life and examining factors related to the trajectories is essential for developing well-targeted PA promotion [8]. While the number of studies identifying trajectories in heterogeneous populations has increased, few have explored determinants of trajectory membership from adolescence to adulthood. Only two studies have been identified, focusing on demographic and socioeconomic factors [9, 10]. In the present study, we aim to expand this approach by also examining psychological and social determinants of life course LVPA trajectories from adolescence to adulthood, spanning over 27 years.

According to a review by Lounassalo et al. [8], three and five LVPA trajectories were identified in two previous studies. The majority of participants in those studies were either in a trajectory of persistently moderate or a trajectory of persistently low levels of PA, with a smaller proportion of participants displaying persistently higher PA levels. One study identified two additional trajectories: an increasingly active or a decreasingly active trajectory. Mathiesen et al. [11] identified four LVPA trajectories. These trajectories were: (a) active ($n=102$, 9%), characterised by a higher level of self-reported LVPA at all measurement points compared to the other three trajectories, (b) decreasingly active ($n=276$, 25%), characterised by starting at a high level at age 13, then decreasing the level of activity in adolescence and having a lower level of activity in adulthood, (c) increasingly active ($n=128$, 12%), persons starting at a low level of LVPA and then

increasing their activity level in adolescence and ending up at the same level as the active trajectory at age 40, and lastly, (d) low active ($n=597$, 54%), consisting of more than half of the participants, characterised by a low level of LVPA in early adolescence and a consistently low level until age 40 years. In addition to identifying the four trajectories, their relation to four activity domains (membership in sports clubs, diversity in leisure-time physical activities, peer PA and outdoor recreation) were explored. Persons in the persistently active trajectory were more involved in all activity domains compared to those in the trajectory of low activity from adolescence to adulthood. Changes in sports club membership, PA among peers, outdoor recreation, and diversity in leisure-time physical activities were related to both an increase or a decrease in the level of LVPA from ages 13 to 40 [11]. The present article is a follow up of these findings, applying data from the same longitudinal study to examine the determinants of the four trajectories.

Previous research on the correlates and determinants of PA calls for a multidimensional approach to understanding PA development. While correlates point to factors that are related to the behaviour in question, determinants indicate some form of causal relationship and are best explored using longitudinal designs [12]. However hard to confirm, some level of causal determination in the relationship between the included factors and LVPA trajectory membership is assumed. Adolescent determinants related to PA development are particularly interesting as adolescence is considered formative years, as individuals gain physical, cognitive, emotional, social, and economic resources to build the foundation for later life health and well-being [13].

Several theories and models include psychological and social determinants of PA. Most prominent are the theory of planned behaviour (TPB) [14], social cognitive theory (SCT) [15] and self-determination theory (SDT) [16]. Cortis et al. [17] recommend integrating these theories to more fully understand the mechanisms underlying PA behaviour. To do so, the differences in the predictive value of the determinants of PA seem to be most informative. The intention to perform PA, as suggested by TPB, has been identified as a major cognitive determinant [17]. In line with SDT, enjoyment is the most important emotional determinant, while intrinsic motivation, identified regulation, and competence are associated with higher PA in all ages [17]. Among the more domain-specific determinants derived from SCT, self-efficacy shows a convincing positive association with overall PA. Athletic identity may also constitute an important psychological determinant of lifelong LVPA because identity plays a significant role in regulating behaviour, as outlined by SDT [18]. Seeing oneself as a PA-oriented person is related to a greater capacity for self-regulation of PA.

Continued PA behaviour can lead to the incorporation of PA as a defining element of participants' self-identity, which then serves as a motivator for continuing to be active [18]. Several studies suggest that those who favour an athletic component of self-concept are more likely to be physically active than those who do not [19].

Different conditions in the immediate social environment affect intentions to engage in PA, enjoyment and value of PA, and perceived competence in PA. Parents serve as primary agents responsible for initiating their children's participation in PA and sports and maintain a vital role in supporting those sports experiences [2, 20]. Social support works in four different ways; evaluative, informative, emotional and instrumental [21]. Parental support in leisure activities such as youth sports and other physical activities may imply that the participant is evaluated and receives feedback on what he/she does, as well as information and knowledge about why such activity is important and how it can best be carried out. Emotional support includes, among other things, encouragement to engage in PA. Instrumental support is provided by the participant getting help to do things, for example, by parents standing up in connection with training and matches. Such support contributes to meeting young people's need for competence and belongingness and strengthens intentions, perceived competence, and enjoyment in PA, which contributes to PA adherence among adolescents [2]. Parents may also affect their children's PA involvement through their PA behaviour, as suggested by the principle of observational learning in SCT. Several studies show that adolescent PA is linked to parental PA, which suggests that parents are effective role models [2, 20].

By utilising more advanced analytic approaches, such as group-based trajectory modelling, one can detect latent classes and reveal different patterns of relationships among several known determinants of PA. The research literature in this area is very limited, but demographic, socioeconomic or behavioural determinants were investigated in two studies [9, 10]. Both studies found that being male increased the odds of belonging to a persistently active trajectory compared to an inactive or low active trajectory. Higher grade point averages [10], higher level of education and higher household income [9] were associated with being in the more active trajectories. Rovio et al. [10] found that parents' PA at age 12 increased the odds of belonging to a decreasingly active trajectory compared to a persistently low active trajectory.

Gender, socioeconomic status and body mass index (BMI) have been found to relate to PA trajectory membership [8] and should therefore be included as possible demographic determinants for trajectory membership.

Consequently, this study aims to examine how demographic (gender, family income, BMI), psychological

(intentions, enjoyment, self-efficacy, self-determination, competence, importance of competence, athletic identity) and social (parental physical activity, support, and encouragement) factors in early adolescence can predict membership in four distinct LVPA trajectories from 13 to 40 years.

Methods

Study population

The Norwegian Longitudinal Health Behaviour Study is two-generational, surveying the same group of respondents ten times (1990–2017) from age 13 to 40, and in addition, their parents three times (in 1990, 1993 and 1996). The sample was drawn from a county on the west coast of Norway and comprised students from 22 randomly selected schools (54 classes) systematically picked from an alphabetic list of schools in the region. Of the initial sample of 1195 students, 924 (78%) participated in 1990, comprising 510 boys (55%), with an average age of 13.3 years. As expected, the number of respondents decreased over the 27 years of follow-up; however, it was acceptable also at the last follow-up in 2017 with 455 respondents.

Before the first measurement point in 1990, all levels of the formal school system were contacted by mail and informed about the study, whereby they accepted the study's goals and agreed to participate. Informed consent from parents or caregivers and approval from the local ethics committee and the Norwegian Data Inspectorate were obtained. The respondents filled in a questionnaire given during school hours at the first three measurement points, after which it was sent to the respondents through the mail. For the data collections in 2007 and 2017, the respondents were also able to fill out the survey online.

The present analysis was based on data from 1103 respondents who participated and reported on the primary outcome variable LVPA at least once over the ten measurement points. Among these 1103 respondents, 17% completed all 10 repeated measurements of LVPA; 15% nine, 11% eight, 9% seven, 10% six, 9% five, 11% four, 10% three, 5% two, and 4% completed only one measurement. Dropout analysis showed no significant differences on baseline values of LVPA or activity domains between those who dropped out of the study before age 40 and the 455 respondents who did not [11].

Leisure-time vigorous physical activity

This was measured using a previously used item from the Health Behaviour in School-aged Children (HBSC) Study: WHO Collaborative Cross-national Study [22], which was included in the questionnaire at all ten measurement points. The question is related to PA outside school/work hours, with vigorous intensity, and maps the frequency of such activity. The question reads, «Outside

school hours, how often do you do sports or exercise to the extent that you become out of breath or sweaty?» with the following response categories (coding in parenthesis): Every day (7), 4–6 times a week (5), 2–3 times a week (2.5), Once a week (1), Once a month (0.25), Less than once a month (0), and Never (0).

There are challenges related to using a single item for mapping a complex behaviour such as LVPA; however, the measure has been found to have acceptable to good reliability in an Australian sample [23] and overall good reliability in an adolescent youth sample in Norway [24]. In terms of validity, the single-item self-reported measure has been found to correlate fairly well with maximal oxygen uptake [24].

Adolescent determinants of LVPA trajectory membership

A total of 17 different adolescent determinants were included in the analysis. All included determinants were collected at baseline in 1990 (age 13), except the information on family income, which was assessed in the questionnaire sent to parents in 1996. The wording of each question, response categories, and coding can be found in an additional file [see Additional file 1].

Three demographic determinants were included, namely gender (binary), BMI (calculated based on self-reported height and weight), and parental reported family income in 1995 (gross household income in intervals of 100 000 NOK).

Five single-item questions related to psychological determinants were used, namely intentions, perceived competence, perceived importance of competence, athletic identity, enjoyment, self-efficacy and self-determination.

Intention for future VPA was measured using two single-item questions related to intentions for performing VPA at different levels in one year or ten years respectively. Perceived competence in PA was measured as the respondents' assessment of their skills in relation to peers, and the perceived importance of competence item was related to how much it mattered to them if they were good or bad in PA. Athletic identity was measured by asking if the respondent thought of themselves as an athlete. Enjoyment was related to affective judgement, while self-efficacy was measured concerning one's perceived ability to execute regular PA (task-specific efficacy). Self-determination was measured by asking the respondent to which degree they could decide how much they participated in sports.

Social determinants related to parents were included, specifically, the respondents' perception of the mother's and father's level of sport or exercise, whether the respondents engaged in sports and exercise with their parents, and instrumental or emotional support from parents.

Analytical Plan

Latent class growth analysis (LCGA) was used to identify LVPA trajectories. The trajectory classes used in the current study have previously been identified and are presented in Fig. 1. Details about the statistical modelling can be found in an additional file [see Additional file 2] and the previously published paper [11]. We performed several multivariate multinomial regression models to investigate which characteristics were significantly predictive of trajectory group membership. First, using the 'savedata' command in Mplus, we created a new variable based on the likelihood of belonging to the four different latent classes. Second, demographic, psychological, and social factors were included as determinants of the latent class belonging variable. Lastly, we repeated the multivariate multinomial regression until each latent class had served as a reference group. All latent class growth curve analyses and multinomial regression models were carried out in Mplus version 8.0 [25], using a number of auxiliary variables collected several times during the 27-year follow-up in the LCGA [11], assuming the data to be missing at random (MAR) and addressed using full information maximum likelihood (FIML) estimation to handle potential construct-level missingness [26]. The model parameters were estimated using the maximum likelihood estimator with robust standard errors (MLR).

Results

Descriptive statistics

The demographic, psychological, and social characteristics of the four physical trajectory groups at age 13 are presented in Table 1. The mean level and percentages followed a systematic pattern across the trajectory groups. A higher level in all variables was observed in the consistently active trajectory group, followed by lower overall means in decreasingly active, increasingly active, and low active groups consecutively.

Adolescent determinants of trajectory class membership

The odds ratio results of the multivariate multinomial regression models are presented in Table 2.

Demographic factors

Women were found to have decreased odds of being active compared to increasingly active (OR=0.42, 95% CI=0.22, 0.81) and low active (OR=0.36, 95% CI=0.20, 0.63). Additionally, women had lower odds of being decreasingly active than increasingly active (OR=0.57, 95% CI=0.34, 0.94) or low active (OR=0.48, 95% CI=0.33, 0.71).

Higher parental reported family income lowered the odds of being decreasingly active compared to increasingly active (OR=0.78, 95% CI=0.62, 0.98).

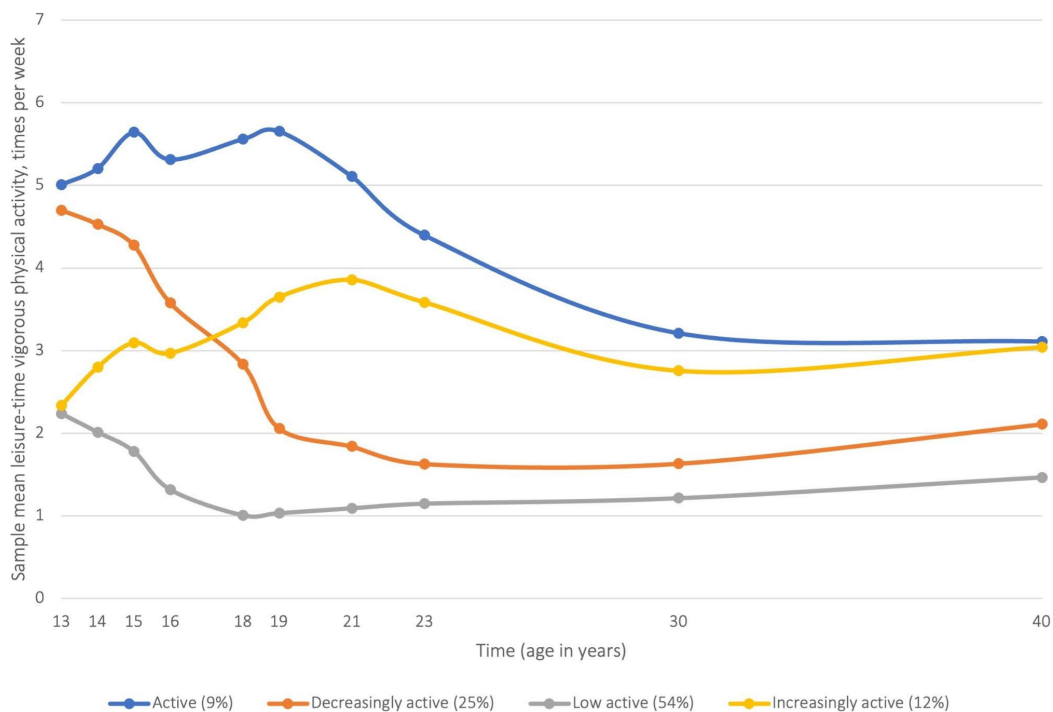


Fig. 1 Leisure-time vigorous physical activity trajectories (n = 1103) from a latent class growth analysis showing sample mean of leisure-time vigorous physical activity (times per week) from age 13 to age 40. Reproduced from Mathisen et al. [11]. The figure is part of an open access article distributed under the terms of the Creative Commons CC BY license, and copyright permissions was not required

Psychological factors

Intentions of higher levels of VPA in one year at age 13 increased the odds of being active rather than increasingly active (OR=3.94, 95% CI=1.92, 8.09) or low active (OR=3.24, 95% CI=1.68, 6.25). Those with intentions of higher levels of VPA in adolescence also had higher odds of being decreasingly active than increasingly active (OR=4.67, 95% CI=3.08, 7.07) or low active (OR=3.84, 95% CI=2.78, 5.31).

Youth with higher intentions of VPA in ten years had lower odds of being decreasingly active than active (OR=0.65, 95% CI=0.47, 0.90) and also had higher odds of being active compared to low active (OR=1.62, 95% CI=1.15, 2.28).

People with higher perceived competence were less likely to be increasingly active than low active (OR=0.65, 95% CI=0.44, 0.97). Participants with higher perceived importance of competence had lower odds of belonging to the decreasingly active compared to the low active trajectory (OR=0.70, 95% CI=0.52, 0.93).

People who identified as an athlete had higher odds of being active than increasingly active (OR=3.68, 95% CI=1.37, 9.92) or low active (OR=4.09, 95% CI=1.70,

9.83). Additionally, they had higher odds of being decreasingly active than low active (OR=2.55, 95% CI=1.54, 4.23) and increasingly active (OR=2.30, 95% CI=1.16, 4.58).

Participants who enjoyed sports had higher odds of being increasingly active than low active (OR=2.52, 95% CI=1.72, 3.68). They were also more likely to be decreasingly active than low active (OR=1.59, 95% CI=1.09, 2.33).

Social factors

People with a physically active mother had higher odds of being in the increasingly active trajectory class than the low active trajectory class (OR=1.24, 95% CI=1.01, 1.53). Participants who experienced emotional support from their father had higher odds of being increasingly active than low active (OR=1.29, 95% CI=1.00, 1.67).

Discussion

In this Norwegian cohort, we identified adolescent determinants for membership in four distinct LVPA trajectories from adolescence to adulthood. Intentions for future VPA in young adulthood were associated with belonging

Table 1 Leisure-time Vigorous Physical Activity Trajectory Distributions, Posterior-Probability Means, and Descriptive Statistics of the Study Sample

Trajectory group Distribution % (n)	Active 9 (102)			Decreasingly active 25 (276)			Increasingly active 12 (128)			Low active 54 (597)		
	n	Mean/%	variance	n	Mean/%	variance	n	Mean/%	variance	n	Mean/%	variance
Posterior probability means	0.84			0.78			0.75			0.87		
Demographic												
Woman	102	25%	0.19	276	34%	0.22	128	51%	0.25	597	54%	0.25
Family income (0–5)	65	3.35	1.47	156	3.35	1.65	79	3.53	1.17	314	3.19	1.55
BMI	68	18.07	7.83	200	17.98	3.23	84	18.25	3.44	395	18.41	5.44
Psychological												
VPA intention, in one year (0–7)	84	5.02	0.83	238	4.90	0.41	106	4.01	0.80	475	3.83	1.07
VPA Intention, in ten years (0–7)	83	4.69	1.18	233	4.25	1.08	105	3.76	1.06	466	3.52	1.54
Perceived competence (0–4)	82	2.49	0.64	236	2.33	0.48	107	1.94	0.39	473	1.94	0.58
Importance of competence (0–3)	85	2.61	0.40	236	2.43	0.51	108	2.32	0.50	471	2.16	0.61
Athletic identity	83	89%	0.10	228	80%	0.16	102	54%	0.25	466	39%	0.24
Enjoyment (0–4)	85	3.86	0.17	238	3.77	0.26	106	3.59	0.37	472	3.16	0.89
Self-efficacy (0–4)	84	3.29	0.73	236	3.14	0.84	106	2.91	0.69	478	2.73	0.87
Self-determination (0–4)	83	3.37	0.69	234	3.37	0.63	107	3.29	0.73	474	3.21	0.85
Social												
Mother's PA (0–4)	84	1.99	1.56	234	1.74	1.43	106	1.79	1.35	473	1.48	1.57
Father's PA (0–4)	83	2.04	1.99	227	1.97	1.67	100	1.63	1.51	463	1.51	1.75
PA together with parents (0–4)	85	1.29	1.29	236	1.06	1.06	106	0.80	0.82	482	0.77	0.81
Instrumental support (0–4)	82	2.44	1.30	236	2.32	1.50	106	1.76	1.36	466	1.59	1.52
Emotional support mother (0–4)	84	2.12	1.99	232	2.00	1.71	106	1.82	1.36	467	1.58	1.53
Emotional support father (0–4)	82	2.11	2.20	228	2.03	1.69	105	1.80	1.53	462	1.42	1.54

BMI=body mass index, PA=physical activity, VPA=vigorous physical activity, Range is presented in parenthesis. The variable categories are found in Additional file 1

to the active trajectory compared to the decreasingly active or low active trajectories, while higher levels of enjoyment increased the odds of belonging to the increasingly or decreasingly active trajectories compared to the low active trajectory. In addition, two of the social determinants, mother's PA and emotional support from father, were associated with belonging to the increasingly active trajectory when compared to the low active trajectory. Lastly, women were less likely to follow the active and decreasingly active trajectories.

Those in the active and decreasingly active trajectories reported similar mean levels on all the determinants. The increasingly active and low activity trajectories also reported similar levels, but consistently lower than those in the active or decreasingly active trajectory groups. This finding may reflect their position at the start of each trajectory, as the LVPA level at age 13 was higher (about 5 times per week) among those in the active and decreasingly active trajectories than in the other two trajectories (about 2.3 times per week) [11]. Thus, they had more familiarity with LVPA and therefore had more opportunities for experiencing enjoyment, self-efficacy, self-determination, competence, perceived importance of competence, athletic identity, and developing intentions, explaining the higher mean levels on almost all the included determinants.

The main distinction between the active versus the decreasingly active trajectories seems to be that those in the former trajectory were more likely to report a higher intention of being physically active in the future, i.e. in young adulthood. This finding is corroborated by the conclusions in a review of determinants of PA [17] and supports the TPB [14]. Those in the active trajectory seem to have experienced a sufficient degree of actual control over engagement in PA over the years, as they have been able to carry out their PA intentions over 27 years.

Among the two trajectory groups starting at the lower end of the scale, those belonging to the increasingly active trajectory reported slightly higher mean levels on all the included determinants than those in the low active trajectory. Higher levels of enjoyment increased the odds of belonging to the increasingly active trajectory. In line with SDT, enjoyment increases the motivation to perform PA because it is intrinsically rewarding.

Enjoyment can be affected by the immediate social environment, where parents are important role models and primary agents for contributing to children's participation in PA and sports. In addition to the increased odds related to enjoyment, we also found that higher levels of mother's PA and emotional support from father increased the odds for belonging to the increasingly active trajectory compared to the low active trajectory.

Exposure to active role models can make the individual more aware of opportunities to engage in LVPA. Increased attention can lead to more positive attitudes towards the activity, which in turn can affect the individual's motivation to initiate and maintain LVPA. Multiple studies on the connection between parental and adolescent PA support that this might be important for PA development [2, 20]. The influence of parental PA on LVPA trajectory membership can, in addition to modelling, also be related to support and encouragement as suggested by previous studies [27] [28].

The results showed a small decrease in the odds of belonging to the increasingly active vs. low active trajectory in relation to higher perceived competence. Due to the documented effect of perceived competence on PA behaviour [17, 29], this unexpected finding may be interpreted carefully due to the small difference in means and large differences in group size between the two trajectory groups. However, the measure of perceived competence was directed at comparing their competence to others, as opposed to other determinants, such as enjoyment, which was internally directed. This might have contributed to the results, as the intrinsic motivation determinants were contributing more to positive development in LVPA. Similarly, we found that higher perceived importance of competence in PA associated with belonging to the low active trajectory compared to the decreasingly active trajectory. We hypothesise that this might also be related to the measure, as the question is related to which degree you care whether you are either good or bad in sports. It is also possible that this item is not as related to the level of LVPA as other factors such as intentions or enjoyment, because the perceived importance of competence in sports can be related to other more external factors, such as social comparison or cultural importance, rather than the individual's competence, motivation for or engagement in sports.

There was a gender difference among the trajectories, and being a woman reduced the odds of belonging to the active and the decreasingly active trajectories. Thus, there were more men in the active and decreasingly active LVPA trajectories, which is consistent with earlier reports [10, 30], and studies showing a larger decrease in PA among boys than girls during adolescence [31].

Lastly, we found that higher levels of parental reported family income gave a slight increase in the odds of belonging to the increasingly active compared to the decreasingly active trajectory. Higher family income may be related to having more time and resources to support and encourage those in the increasingly active trajectory to engage and maintain their LVPA involvement throughout the adolescent years.

Table 2 Adolescent determinants of leisure-time vigorous physical activity trajectories

	Decreasingly active vs active ^a		Increasingly active vs active ^b		Decreasingly active vs low active ^c		Increasingly active vs increasingly active ^c		Active vs low active ^b		Decreasingly active vs low active ^b	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Demographic												
Woman	1.35	0.78, 2.36	0.85	0.56, 1.30	0.57	0.34, 0.94	0.42	0.22 , 0.81	0.36	0.20 , 0.63	0.48	0.33 , 0.71
Family income	0.98	0.75, 1.28	1.23	0.99, 1.52	0.78	0.62 , 0.98	0.80	0.58, 1.09	0.98	0.73, 1.31	0.96	0.79, 1.16
BMI	0.91	0.78, 1.06	1.00	0.90, 1.11	0.95	0.84, 1.07	1.04	0.88, 1.23	1.04	0.89, 1.21	0.95	0.86, 1.04
Psychological												
VPA Intention, in one year	1.19	0.67, 2.10	0.82	0.62, 1.10	4.67	3.08 , 7.07	3.94	1.92 , 8.09	3.24	1.68 , 6.25	3.84	2.78 , 5.31
VPA Intention, in ten years	0.65	0.47 , 0.90	1.12	0.89, 1.40	0.94	0.72, 1.24	1.45	0.99, 2.12	1.62	1.15 , 2.28	1.05	0.85, 1.30
Perceived competence	0.83	0.56, 1.22	0.65	0.44 , 0.97	1.34	0.87, 2.07	1.62	0.97, 2.71	1.05	0.69, 1.61	0.87	0.64, 1.20
Importance of competence	0.81	0.52, 1.27	1.00	0.73, 1.37	0.70	0.48, 1.02	0.86	0.52, 1.42	0.86	0.56, 1.34	0.70	0.52 , 0.93
Athletic identity	0.63	0.26, 1.53	1.11	0.63, 1.97	2.30	1.16 , 4.58	3.68	1.37 , 9.92	4.09	1.70 , 9.83	2.55	1.54 , 4.23
Enjoyment	0.79	0.38, 1.64	2.52	1.72 , 3.68	0.63	0.39, 1.04	0.80	0.37, 1.74	2.01	0.99, 4.08	1.59	1.09 , 2.33
Self-efficacy	0.94	0.68, 1.31	1.01	0.77, 1.32	0.95	0.68, 1.31	1.01	0.67, 1.51	1.02	0.72, 1.43	0.95	0.76, 1.20
Self-determination	1.08	0.76, 1.53	1.07	0.84, 1.36	1.05	0.78, 1.41	0.97	0.65, 1.45	1.04	0.72, 1.49	1.12	0.89, 1.41
Social												
Mother's PA	0.83	0.65, 1.06	1.24	1.01 , 1.53	0.82	0.65, 1.05	1.00	0.74, 1.34	1.24	0.96, 1.59	1.02	0.86, 1.22
Father's PA	1.20	0.93, 1.54	0.95	0.78, 1.16	1.24	0.98, 1.56	1.04	0.76, 1.41	0.98	0.75, 1.29	1.17	0.98, 1.41
PA together with parents	0.83	0.61, 1.12	0.89	0.67, 1.18	1.05	0.77, 1.44	1.27	0.87, 1.85	1.12	0.82, 1.55	0.93	0.74, 1.18
Instrumental support	1.07	0.81, 1.41	0.91	0.74, 1.11	1.26	0.99, 1.60	1.18	0.87, 1.61	1.07	0.82, 1.40	1.15	0.95, 1.38
Emotional support mother	0.97	0.69, 1.36	0.97	0.76, 1.25	1.07	0.81, 1.42	1.11	0.75, 1.62	1.08	0.77, 1.50	1.05	0.86, 1.27
Emotional support father	1.11	0.79, 1.55	1.29	1.00 , 1.67	0.77	0.58, 1.03	0.70	0.47, 1.03	0.90	0.65, 1.26	1.00	0.81, 1.23

BMI=body mass index, PA=physical activity, VPA=vigorous physical activity

The values are odds ratios (OR) and 95% confidence intervals (95% CI). All determinants are entered simultaneously. Statistically significant (P < .05) results are marked with bold font

^aActive trajectory was used as the reference category

^bLow active trajectory was used as the reference category

^cIncreasingly active trajectory was used as the reference category

Limitations

One limitation of this study might be the single-item measurements of the adolescent determinants and frequency of LVPA. Using a single item to measure LVPA may have oversimplified a phenomenon with many dimensions, such as type of activity or duration. Single indicators have decreased levels of detail, unknown reliability, and might not capture complex psychological constructs [32]. Thus, because self-efficacy and self-determination are commonly measured as latent constructs, we advise caution in interpreting the results pertaining to the predictive power of these factors. However, the other determinants measured in this study are not assumed to be complex constructs but rather one-dimensional, clear, and simple questions pertaining to personal enjoyment, intentions, and beliefs of sports participation, as well as the availability of environmental resources. As Bowling [33] notes: if one question works, why ask several? If single items appropriately measure what they are meant to assess, multiple indicator scales might not necessarily be favourable over single indicators [32]. We argue that the indicators in this study have strong face validity. Indeed, items are worded similarly to indicators in scales, such as the Athletic identity measurement scale (AIMS) [34] and the Physical Activity Enjoyment Scale (PACES) [35]. Furthermore, single-item measures are vastly more cost-effective and parsimonious regarding efficiency and utility [32], which are crucial aspects in longitudinal studies spanning 27 years or more.

The usage of self-reported data in this study might be considered another limitation. For one, people might under or overreport due to social desirability [36, 37], which can lead to a misrepresentation of the data. However, the indicators in this study were designed to be as neutral as possible [38], except for the perceived competence indicator, wherein participants are to compare themselves to peers regarding sports proficiency. The survey and administration were designed to be non-threatening and self-administered [38]. Participants were given random numbers for their identification instead of their names and put the completed surveys in sealed envelopes. Secondly, common method bias (e.g., [39]) might pose a threat to the discriminative validity of the measurements in the data. For instance, it is possible that the variance in the adolescent determinants measured in this study is explained by one single latent construct. To examine this possibility, we performed a post hoc Harman's single-factor test [40], which included all determinants in the study. The results clearly showed that several latent factors were extracted, indicating that common method variance does not pose a large threat to the discriminative validity of the variables in this study.

Another limitation of the study might be that the sample is not representative of the Norwegian population.

However, because the study is of such magnitude in terms of duration and resource expenditure, it would be near impossible to follow up on a more extensive sample size over 27 years. Further, the baseline mean of LVPA collected in October/November 1990 was almost identical to the nationally representative HBSC study sample of Norwegian 13-year-olds ($n=1616$) in November 1989. Hence the sample from western Norway at baseline was representative of the relevant age group in Norway [41].

Following the same group of individuals over 27 years entails challenges related to wave nonresponse. The level of missing data was high. However, dropout analyses were conducted [11] and the missing data were assumed to be MAR and handled using FIML with several auxiliary variables in the analysis, which has been shown to reduce the chance of inadvertently omitting an important cause of missingness, and also increases efficiency and reduces bias [42]. Lastly, group-based modelling reduces by approximation to summarise data, comparing individuals that are not entirely homogenous. It is important to recognise that the analysis gives only the probability of following a trajectory.

Conclusions

Demographic, psychological, and social determinants for membership in LVPA trajectories were identified in this longitudinal study with a 27-year follow-up. Men, those with a stronger athletic identity and with intentions of higher levels of VPA the next year were more likely to belong to the two trajectories starting with the highest levels of LVPA at age 13. Comparing these two trajectories, higher intentions for VPA in ten years increased the odds of belonging to the active compared to the decreasingly active trajectory. Enjoyment increased the odds of belonging to the increasingly active trajectory compared to the low active. Supporting the development of intentions for and the experience of enjoyment in PA during adolescence may promote persistence in or increase such health-promoting behaviour during the crucial and formative years of behavioural development.

We argue that the findings provide valuable information on how determinants at a young age might impact physical activity behaviour in a life course perspective. For example, the implications of the findings in this study might be relevant to the field of PA and health promotion practitioners aiming to increase physical activity across the lifespan. However, as our results are related to leisure-time and VPA only, future research should also study the relationship between trajectories for moderate or total PA and adolescent determinants.

List of Abbreviations

BMI	Body mass index
FIML	Full information maximum likelihood

HBSC	The Health Behaviour in School-aged Children (HBSC) Study:WHO Collaborative Cross-national Study
LCGA	Latent class growth analysis
LVPA	Leisure-time vigorous physical activity
MAR	Missing at random
PA	Physical activity
VPA	Vigorous physical activity

Supplementary Information

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Additional file 1: Questionnaire items

Additional file 2: Latent class growth analysis

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Authors' contributions

FKSM, SMK and BW prepared the outline for the first draft and created a data analysis plan. FKSM and SMK conducted the analysis and prepared the first draft of the manuscript. CF and BW contributed to the interpretation of the results and critically reviewed the manuscript. All authors read and approved the final manuscript.

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Data Availability

The data and materials used for the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the Data Protection Services at the Norwegian Centre for Research Data and REC West (regional ethics committee). It was conducted in full accordance with the ethical principles of the Declaration of Helsinki. Written informed consent from parents and participants was required prior to participation in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Additional file 1

Questionnaire items

A list of all questionnaire items used to measure the included determinants, providing the wording all items, response categories and coding used in the analysis.

Questionnaire Item	Response categories	Coding
<i>Demographic</i>		
Are you a boy or a girl?	Boy	0
	Girl	1
Height	cm	
Weight	kg	
What was your household's total income in 1995 (gross)?	Less than 100.000	0
	100-199.000 or more	1
	200-299.000	2
	300-399.000	3
	400-499.000	4
	500.000 or more	5
<i>Psychological</i>		
Think about yourself in one year. How many times per week do you think you will do sports or exercise to the extent that you become out of breath or sweat?	Every day	7
	4-6 times a week	5
	2-3 times a week	2,5
	Once a week	1
	Once a month	0,25
	Less than once a month	0
Think about yourself in ten years. How many times per week do you think you will do sports or exercise to the extent that you become out of breath or sweat?	Every day	7
	4-6 times a week	5
	2-3 times a week	2,5
	Once a week	1
	Once a month	0,25
	Less than once a month	0
Think about many different sports outside school. How good are you normally in sports?	Better than peers	4
	Slightly better than peers	3
	As peers	2
	Slightly worse than peers	1
	Worse than peers	0
How much does it matter to you whether you are good or bad at sports?	It means a lot	3
	It means some	2
	It means little	1
	It doesn't mean anything	0
Do you think of yourself as a sports girl/boy?	Yes	1
	No	0

How do you enjoy doing sports?	Very much	4
	Enjoy it	3
	Neither good nor bad	2
	Bad	1
	Very bad	0
How easy would it be for you to engage in sports or exercise, should you wish to do so?	Very easy	4
	Easy	3
	Neither easy nor difficult	2
	Difficult	1
	Very difficult	0
Do you feel that you can decide for yourself how much you are going to participate in sports?	I decide for myself a great deal	4
	I can decide for myself a lot	3
	I can decide for myself to some degree	2
	I can decide for myself a little	1
	I cannot decide for myself much	0
<i>Social</i>		
Do your mother/father do sports or exercise?	4 times per week or more	4
	2-3 times a week	3
	Once a week	2
	Less than once a week	1
	Never	0
	I don't have a mother/father	Missing
Do you happen to do sports or exercise together with your mother or father?	4 times per week or more	4
	2-3 times a week	3
	Once a week	2
	Less than once a week	1
	Never	0
Does it happen that your parents help you do sports? (It can be such things as driving or picking you up, timing, keeping scores or similar.)	4 times per week or more	4
	2-3 times a week	3
	Once a week	2
	Less than once a week	1
	Never	0
How often do your mother/father encourage you to do sports or exercise to keep fit?	4 times per week or more	4
	2-3 times a week	3
	Once a week	2
	Less than once a week	1
	Never	0

Additional file 2

Latent class growth analysis

Before performing the latent class growth analysis (LCGA) in Mplus, version 8.7, data on leisure-time vigorous physical activity (LVPA) collected at all ten measurement points were modelled in latent growth models to test what number of growth parameters best fitted the data. The three models ranged from two to four growth parameters, where the best fit was obtained when the model included four growth parameters (intercept, slope, quadratic, and cubic slope factor). This was determined by the highest comparative fit index (CFI=0.911) and the lowest root mean square error of approximation (RMSEA=0.05). The same data and number of growth parameters were used in the LCGA.

LCGA is a type of group-based trajectory model, making it possible to identify classes of individuals based on their joint growth over time (1). The LCGA was performed by treating the ten measures of LVPA as continuous and together with several auxiliary variables related to activity domains (e.g., membership in sports clubs, diversity in leisure-time activity, peer PA) collected in adolescence, young adulthood and adulthood.

Data were assumed to be missing at random (MAR) and handled using full information maximum likelihood estimation (FIML). The maximum likelihood estimator with robust standard errors (MLR) was used when estimating the model parameters. To determine the fit and interpretability of the model and number of latent trajectory classes the Akaike information criteria (AIC), Bayesian information criteria (BIC), entropy, average posterior probability >0.70 for within-group membership, the Vuong–Lo–Mendell–Rubin test (VLMR), and the bootstrap likelihood ratio test (BLRT) were used (2). The model fit for two, three, four, five, six and seven latent trajectory classes were assessed. The final class enumeration was based on entropy and posterior probability of class membership, along with theoretical and empirical support for the four-class solution.

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Leisure-time physical activity and participation in organized sports: Changes from 1985 to 2014 in Finland and Norway

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Participation in organized sports is a popular and important part of the lives of children and adolescents and is associated with improved psychological and social health, as well as an increased likelihood of meeting physical activity (PA) recommendations. Changes in modern society, including increased car ownership and use of technology and electronic media, have led to an additional focus on the importance of health-enhancing PA among children and adolescents. The aim of this article was to study the secular changes in self-reports of participation in organized sports clubs and leisure-time vigorous physical activity (LVPA), and whether the relationship between participation in organized sports clubs and LVPA has changed from 1985 to 2014. Questionnaire data were collected in two cross-sectional samples of Finnish and Norwegian 11-, 13- and 15-year-olds in 1985/1986 (n = 7137) and 2014 (n = 9218). Overall, participation in organized sports clubs and level of LVPA appears to have changed in the same direction in the two Nordic countries. The proportion of 11-year-olds reporting to be participants in organized sports clubs increased from 1985/1986 to 2014. There was an overall increase in self-reported LVPA. The association between participation in sports clubs and LVPA was stronger in 2014 than in 1985/1986. The findings indicated subgroup differences, in particular with regard to a steeper increase in LVPA and participation in sports clubs among Finnish girls. We suggest that attention should be given to the role of organized sports to better understand secular changes in PA.

KEYWORDS

adolescent, exercise, HBSC, member, time change, youth

1 | INTRODUCTION

Increased car ownership and the use of electronic media and technology have raised concerns about increases in sedentary behavior leading to a decrease in health-promoting physical activity among children and adolescents.¹ Physical activity (PA) is associated with numerous health benefits in school-aged children and adolescents and

appears to follow a dose-response relationship.² The global recommendation for health-enhancing physical activity for children and adolescents is 60 minutes of moderate to vigorous physical activity (MVPA) a day. Vigorous physical activity (VPA) is recommended at least three times per week.² VPA is a subdomain of physical activity and connected to young people's recreational hobbies and sports outside school.³

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Recent reviews on temporal trends in PA levels among children and adolescents have documented inconsistent trends in different contexts of PA,^{4,5} although the evidence for a decline in activity in clearly defined contexts, such as active transport, is more consistent. The variation in methodology and measurements makes it difficult to present a coherent picture of the development in PA. A recent report from the Health Behaviour in School-aged Children (HBSC) study³ found an increase from 2002 to 2014 in prevalence of self-reported leisure-time VPA (LVPA) among 11-, 13-, and 15-year-olds in several countries, including Norway. In Finland however, there was a decrease in LVPA among boys over this time period. Others have found, based on objective measures, a decrease in overall PA among Norwegian children and adolescents over a similar time period.⁶ Trends in young people's PA can be linked to macro-environmental and demographic changes, typical of developed countries, such as less space for play in urban contexts, increased concerns about safety, changes in the roles of significant others,⁷ and innovations within the sports and exercise domain.

In a modern lifestyle, time after school has an important potential for physical activity in the lives of children and adolescents. Structured leisure-time activities might contribute to higher levels of intrinsic motivation and positive youth development⁸ and are associated with better physical and mental health among adolescents.⁹ In contrast to other Western countries, like the United States and UK, organized sports in northern Europe and the Nordic countries in particular is strongly related to time after school, and there has been little or no collaboration between school and sports clubs.¹⁰ It is estimated that 88% in Finland¹¹ and 70%-80% of all children in Norway¹² at some point during their childhood or adolescence are members of a sports club or team. Organized sports provide structures for play, social interaction, and the development of skills. More than other forms of leisure-time PA for children and adolescents, participation in organized sports clubs is associated with improved psychological and social health,¹³ increased likelihood of meeting PA recommendations,¹⁴⁻¹⁶ and higher levels of VPA.¹⁶⁻¹⁸ Furthermore, membership in sports clubs during adolescence predicts higher levels of leisure-time PA in adulthood.^{19,20}

Previous trend studies in four different European countries showed an increase in organized sports participation among children and adolescents.^{10,21-23} Participation in sports clubs has increased in Finland over the last ten and twenty years, as the proportion of participants was 48% for boys and 44% for girls in 2010, and 46% for boys and 34% for girls in 1990.²⁴ In Norway, studies have found relatively stable numbers of membership in organized sports clubs from 1992 to 2010.²⁵ In 1987, the Norwegian Provisions on Children's Sports was passed, stating that children's sports, up to the age of 13, should be based on versatility and play.²⁶ This included limiting early specialization, only allowing children under the age

of 10 to participate in competitions in their local sports club or local community and banning schedules and lists of results for children under the age of 12.¹² In 2007, the provision was revised, with a new section focusing on children's rights in sports and a simplified language.²⁶

However, participation in organized sports decreased from 1992 to 2010 among older adolescents in Norway.²⁵ The decrease in participation among older adolescents may relate to an increased focus on specialization and pressure both within organized sports and from school.²⁷ A Swedish study found that from 1974 to 1995, adolescents participated less in traditional team sports activities, while interest and participation in keep-fit activities outside traditional sports clubs increased. The authors suggest that this could partly be explained by a larger range of activities offered in 1995 compared to 1974 and by increased body and health awareness.²³

New, informal sports, such as keep-fit activities, jogging, strength training, cross fit, hiking, and skateboarding, have gained increasing popularity among adolescents.^{23,28} Informal sports do not require adolescents to be part of organized official sports clubs,²⁸ but may involve high levels of LVPA. Thus, the introduction of new types of physical activities may contribute to a change in the importance of participating in organized sports clubs for adolescents' LVPA levels. This may be even more relevant for older adolescents, as they may be more likely to choose these new types of activities than younger adolescents may, the latter being more constrained by parents and caretakers in their choice of leisure-time activities. Previously, the importance of participation in organized sports for level of overall PA and LVPA has been documented in cross-sectional studies,^{14,17,29} and changes over time have not been identified.¹⁸ To this end, Ekelund et al⁵ called for repeated cross-sectional surveys of population-representative samples in order to properly examine the magnitude and direction of recent changes in PA levels and sports participation of adolescents.⁵

The aim of this study was to examine changes from 1985 to 2014 in self-reported participation in organized sports clubs and LVPA among Finnish and Norwegian children and adolescents and to what extent the association between self-reports of participation in organized sports clubs and adolescents' LVPA levels has changed over this time in the two countries.

2 | METHODS

2.1 | Procedures

This study uses data from the Finnish and Norwegian contributions to the repeated cross-sectional study, Health Behaviour in School-aged Children (HBSC), a WHO cross-national survey. This international study is carried out in collaboration with WHO/EURO every 4 years on nationally

representative samples of 11-, 13-, and 15-year-olds.³⁰ The present paper presents data collected at two time points in 1985/1986 (November-December 1985 in Norway and February-March 1986 in Finland) and 2013/2014 (March-May 2014 in Finland and March 2014-January 2015 in Norway). Other time points or HBSC countries were not included in the analysis as the item on participation in organized sports clubs was not present in any of the other national HBSC surveys in both 1985 and 2014.

Informed passive consent, including, voluntary participation, possibility to withdraw at any time without specific reason and full anonymity throughout the study, was obtained from the pupils' primary guardians and all pupils gave voluntary informed consent. In accordance with the international protocol of the HBSC study, 90% of the sample in each age group fell between half a year of a mean age of 11.5, 13.5, and 15.5 years. The respondents anonymously completed the questionnaires during one lesson period at school with their teacher following a standard set of instructions. The respondents were informed about the study and that participation was voluntary. In 1985/1986, the questionnaire was paper based in both countries, as was the questionnaire in Finland in 2014, while the schools could choose a paper-based or a web-based questionnaire in Norway. At both time points, the Data Protection Official for Research at the Norwegian Center for Research Data assured that the study complied with the ethical requirements for privacy and confidentiality. The Finnish HBSC study was approved by the Finnish Teachers Trade Union and the Finnish National Agency for Education when the survey was collected the first time in 1986 and the procedure has been the same since. Data collection has followed the existing ethical guidelines with passive consent procedure.

2.2 | Sample

A total of 16 482 (Table 1) 11-, 13-, and 15-year-olds participated in the surveys in 1985/1986 and 2014 (student response rates among participating schools were 89% and 85% in Finland and 91% and 92% in Norway, respectively). In Finland, the samples were chosen from the Finnish school register by using a special sampling program. The sample frame was the number of pupils at each class level. Schools were selected using a cluster sampling method that took the size of the schools (PPS, probability proportionate to size) into account. Inside a selected school, one class was randomly selected. In Norway, school classes were used as primary sampling units, with a standard cluster sampling procedure based on a graphical stratified list and sequential selection from a randomized starting point. If a school agreed to participate, all pupils from one class per age group were selected.

2.3 | Measures

Two self-reported questions regarding the respondents' LVPA and participation in organized sports clubs were used as the basis of our analysis, as these questions were identical at both time points and included in the questionnaires for all age groups. LVPA was measured with the item "OUTSIDE SCHOOL HOURS: How often do you usually exercise in your free time so much that you get out of breath or sweat?". The item had seven response categories (coding given in parenthesis): Every day (7), 4-6 times a week (5), 2-3 times a week (2.5), Once a week (1), Once a month (0.25), Less than once a month (0), or Never (0).

	1985/1986			2014		
	n	Mean age	SD	n	Mean age	SD
Finland						
11-year-old boys	578	11.7	0.29	963	11.8	0.28
11-year-old girls	589	11.6	0.29	1020	11.8	0.27
13-year-old boys	465	13.6	0.30	943	13.8	0.30
13-year-old girls	461	13.6	0.30	944	13.8	0.30
15-year-old boys	543	15.7	0.31	956	15.8	0.31
15-year-old girls	546	15.6	0.29	1009	15.8	0.29
Norway						
11-year-old boys	720	11.5	0.30	689	11.6	0.32
11-year-old girls	642	11.4	0.29	700	11.6	0.31
13-year-old boys	612	13.4	0.30	505	13.6	0.31
13-year-old girls	690	13.4	0.30	540	13.6	0.32
15-year-old boys	667	15.5	0.30	454	15.6	0.29
15-year-old girls	624	15.4	0.30	495	15.5	0.30

TABLE 1 Sample size, mean age, and standard deviation by country, age group, gender, and survey year

This LVPA item has previously been assessed and been found to have acceptable to good reliability in an Australian sample³¹ and overall good reliability in a Norwegian sample aged 13-18 years (intraclass correlations, 0.59-0.87).²⁹ In terms of validity, the item has shown statistically significant correlations ($r = 0.39$) with physical fitness (maximal oxygen uptake)³² and partial validity, showing higher scores on a 20-m shuttle run test for those who reported higher activity levels than others.

Participation in organized sports clubs was measured using a single question: "Are you a member of a sports club?", with response categories being No (1), Yes, I train in a sports club (2), and Yes, but I don't attend training sessions (3). A small number of respondents indicated that they were members of a sports club, but did not attend training sessions (Finland: $n = 313$ in 1985/1986 and $n = 183$ in 2014, Norway: $n = 258$ in 1985/1986 and $n = 76$ in 2014). Analyses performed with the non-attending participants included in the study showed only minor, nonsignificant differences from the active participant group (results not shown). To interpret the results more precisely and reflect upon the differences between non-participants and participants in sports clubs, we excluded the 830 passive members from further analysis and used a dichotomized version of the item (No = 0, Yes, I train in a sports club = 1).

2.4 | Analysis

We performed the statistical analysis using IBM SPSS Statistics version 24. To analyze secular changes and gender

differences in participation in organized sports clubs and level of LVPA, we used Pearson chi-square and independent sample t test. Cohen's d was calculated to produce effect sizes by using calculator at www.psychometrica.de.

The primary dependent variable in the current analysis was LVPA. Five discrete independent factors were included as follows: country, gender, survey year, participation in organized sports clubs, and age group. To account for classroom effects appropriately, all models were specified as two-level regression models, modeling a random intercept for school class as the primary sampling unit. A full linear mixed model including all main and interactive effects was estimated using restricted maximum likelihood. Omnibus significance test for each independent factor was assessed by means of type III F tests using Satterthwaite corrected degrees of freedom. For the purpose of interpreting findings, estimated marginal means were estimated, with simple effects of survey year by country, participation group, gender, and age group.

3 | RESULTS

Table 2 shows the proportion of respondents reporting to be participants in sports clubs by gender, country, age, and year. Compared with 1985/1986, more 11-year-old girls and boys reported participation in organized sports clubs in 2014, with small to medium effect sizes. The difference was largest among Finnish 11-year-old girls, with an increase of 20 percentage points in participation. With the exception of Finnish girls, the results showed a tendency for none or reduced

TABLE 2 Percentage of respondents participating in organized sports clubs in 1985/1986 and 2014

	Boys				Girls											
	1985/1986		2014		Time difference		Effect size		1985/1986		2014		Time difference		Effect size	
	n	%	n	%	χ^2	d	n	%	n	%	χ^2	d				
Finland																
11-year-olds	279	53	555	59	5.74*	0.13	186	35	533	54	52.89**	0.38				
13-year-olds	194	46	414	46	0.01	0.02	143	34	439	48	23.08**	0.27				
15-year-olds	189	39	325	36	1.34	0.06	130	27	364	38	15.15**	0.21				
Norway																
11-year-olds	470	70	425	78	10.39**	0.19	356	60	425	72	19.11**	0.26				
13-year-olds	360	63	265	66	1.20	0.07	384	59	281	63	2.13	0.09				
15-year-olds	374	62	206	55	4.35*	0.13	300	53	196	47	4.10*	0.13				

Note. Gender differences in 1985/1986 Finland: 11 y ($\chi^2 = 36.46$, $P < 0.001$, $d = 0.38$), 13 y ($\chi^2 = 12.11$, $P = 0.001$, $d = 0.24$), 15 y ($\chi^2 = 13.86$, $P = 0.008$, $d = 0.24$). Gender differences in 2014 Finland: 11 y ($\chi^2 = 5.59$, $P = 0.018$, $d = 0.11$), 13 y ($\chi^2 = 1.28$, ns), 15 y ($\chi^2 = 0.98$, ns). Gender differences in 1985/1986 Norway: 11 y ($\chi^2 = 12.26$, $P < 0.001$, $d = 0.20$), 13 y ($\chi^2 = 2.26$, ns), 15 y ($\chi^2 = 8.90$, $P = 0.003$, $d = 0.18$). Gender differences in 2014 Norway: 11 y ($\chi^2 = 4.66$, $P = 0.031$, $d = 0.13$), 13 y ($\chi^2 = 0.97$, ns), 15 y ($\chi^2 = 5.60$, $P = 0.018$, $d = 0.17$).

χ^2 , Pearson chi-square.

* $P < 0.05$.

** $P \leq 0.001$.

changes in participation rates among older adolescents. The gender differences in participation in sport clubs declined during the period, with a higher proportion of boys than girls in 1985/1986 compared to 2014, especially in Finland.

In general, the mean levels of LVPA were higher in 2014 than in 1985/1986 (Table 3). Among girls, the effect sizes were medium to large, amounting to more than one time LVPA more per week. Among boys, the differences were small to medium, and no statistically significant time difference in LVPA was detected in the two oldest age groups in Finland. In line with the findings on self-reported participation in sports clubs, gender differences in LVPA declined in Finland and were non-existent in the two oldest age groups in 2014. In Norway, however, boys reported a higher level of LVPA than girls at both time points.

Linear mixed model analysis was performed to establish whether LVPA differed according to country, gender, age group, participation in organized sports clubs, and survey year (Table 4). There were significant main effects of all independent variables. As shown in Table 5, the activity levels were generally higher in 2014, among boys, and among those in organized sports clubs. Inspection of the means in Table 5 reveals that the effects of age and country were negligible, although statistically significant. With regard to difference over time, there was a two-way interaction (Table 4) between survey year and participation in sports clubs on LVPA, indicating that the effect of participation in organized sports clubs differed across survey year. Table 5 shows that this difference concerns a stronger association between participation in sports clubs and LVPA in 2014 compared to 1985/1986, that is in 2014, participants in sports clubs reported higher levels of LVPA compared to non-participants than was the case in 1985/1986. There was a two-way interaction effect of survey year and gender. The means depicted in Table 3 suggest that this effect is due to the relatively steeper increase over time in LVPA among girls compared to boys. Figure 1 illustrates the significant three-way interaction effect between participation in organized sports clubs, country, and survey year on LVPA shown in Table 4. In Finland, the increase in the association between participation and LVPA over time was less pronounced than in Norway. Figure 2 illustrates the three-way interaction between gender, country, and survey year. From 1985/1986 to 2014, the effect of gender on LVPA changed more in Finland than in Norway, indicated by a steeper increase in activity among Finnish girls.

4 | DISCUSSION

Overall, participation in organized sports clubs and level of LVPA appears to have changed in the same direction in the two Nordic countries. The proportion of 11-year-olds reporting to be participants in organized sports clubs increased

TABLE 3 Mean levels, standard deviations, and *t* test values of times per week in leisure-time vigorous physical activity in 1985/1986 and 2014

	Boys						Girls										
	1985/1986			2014			1985/1986			2014			Time difference		Effect size		
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>d</i>	<i>t</i>	<i>d</i>	
Finland	11-year-olds	577	2.97	2.21	956	3.39	2.39	3.45*	0.18	589	2.21	1.83	1011	3.13	2.27	-8.86*	0.43
	13-year-olds	463	3.26	2.31	887	3.38	2.39	-0.91	0.05	461	2.25	1.88	927	3.26	2.29	-8.81*	0.47
	15-year-olds	540	3.11	2.38	928	3.36	2.46	-1.86	0.10	546	2.19	2.00	994	3.40	2.33	-10.71*	0.55
Norway	11-year-olds	718	3.22	2.10	583	3.96	2.12	-6.29*	0.35	641	2.52	1.81	627	3.49	1.96	-9.12*	0.51
	13-year-olds	611	2.97	1.90	426	3.68	2.14	-5.49*	0.35	689	2.67	1.87	476	3.36	1.94	-6.01*	0.36
	15-year-olds	666	3.03	2.11	393	3.80	2.37	-5.34*	0.34	623	2.61	1.95	446	3.37	2.04	-6.17*	0.38

Note. Gender differences in 1985/1986 Finland: 11 y ($t = 6.42, P < 0.001, d = -0.38$), 13 y ($t = 7.32, P < 0.001, d = -0.48$), 15 y ($t = 6.96, P < 0.001, d = -0.42$). Gender differences in 2014 Finland: 11 y ($t = 2.51, P = 0.012, d = -0.11$), 13 y ($t = 1.08, ns$), 15 y ($t = -0.34, ns$). Gender differences in 1985/1986 Norway: 11 y ($t = 6.55, P < 0.001, d = 0.36$), 13 y ($t = 2.86, P = 0.004, d = 0.15$), 15 y ($t = 3.74, P < 0.001, d = 0.21$). Gender differences in 2014 Norway: 11 y ($t = 4.02, P < 0.001, d = 0.23$), 13 y ($t = 2.36, P = 0.02, d = 0.16$), 15 y ($t = 2.82, P = 0.005, d = 0.19$).

* $P < 0.001$

TABLE 4 Univariate analysis of variance testing interaction effects of gender, age group, participation in organized sports clubs, and survey year on times per week in leisure-time vigorous physical activity (N = 14 760)

Variable	Numerator <i>df</i>	Denominator <i>df</i>	<i>F</i>	<i>P</i>
Intercept	1	838.19	20623.90	<0.001
Survey year (Y)	1	838.19	187.44	<0.001
Gender (G)	1	14599.62	116.55	<0.001
Age group (A)	2	866.92	16.42	<0.001
Participation in organized sports clubs (P)	1	14626.74	2588.11	<0.001
Country (C)	1	838.19	7.28	0.007
Y * G	1	14599.62	24.88	<0.001
Y * A	2	866.92	2.10	0.123
Y * P	1	14626.74	27.94	<0.001
Y * C	1	838.19	2.13	0.145
G * A	2	14596.74	1.18	0.307
G * P	1	14696.66	5.94	0.015
G * C	1	14599.62	3.05	0.081
A * P	2	14629.69	49.88	<0.001
A * C	2	866.92	6.74	0.001
P * C	1	14626.74	10.84	0.001
Y * G * A	2	14596.74	0.31	0.733
Y * G * P	1	14696.66	2.55	0.110
Y * G * C	1	14599.62	14.38	<0.001
Y * A * P	2	14629.69	1.41	0.245
Y * A * C	2	866.92	0.32	0.725
Y * P * C	1	14626.74	13.05	<0.001
G * A * P	2	14696.65	0.83	0.435
G * A * C	2	14596.74	1.99	0.137
G * P * C	1	14696.66	0.15	0.699
A * P * C	2	14629.69	4.16	0.016
Y * G * A * P	2	14696.65	0.83	0.435
Y * G * A * C	2	14596.74	1.41	0.243
Y * G * P * C	1	14696.66	1.88	0.170
Y * A * P * C	2	14629.69	2.17	0.114
G * A * P * C	2	14696.65	0.88	0.415
Y * G * A * P * C	2	14696.65	0.08	0.924

from 1985/1986 to 2014. There was an overall increase in self-reported LVPA. The association between participation in sports clubs and LVPA was stronger in 2014 than in 1985/1986. The findings indicated subgroup differences, in particular with regard to a steeper increase in LVPA and participation in sports clubs among Finnish girls.

The increase in participation among the 11-year-olds is consistent with the results in other European studies.^{10,21,22} A Norwegian study has indicated that children in 2006 started participating in sports at an earlier age than before.¹² This is also a prevalent trend in Finland, as the involvement in

organized sports starts younger today, on average at the age of six. One explanation can be that the strong public debate concerning low levels of PA among children and adolescents has made parents regard sports participation as a major solution for PA promotion among their children.¹¹

Fewer 15-year-olds in Norway reported participating in organized sports clubs in 2014 compared to 1985/1986. In another Norwegian study, more respondents dropped out of organized sports by the age of 15 in 2010 than in 1992.²⁵ The observed change among 11- and 15-year-olds might be based on earlier recruitment into organized sports, which may result

TABLE 5 Means, standard error, and univariate tests for the simple effects of survey year on times per week in leisure-time vigorous physical activity for boys and girls within each age group and country for non-participants and participants in organized sports clubs

	Gender	1985/1986		2014		Numerator <i>df</i>	Denominator <i>df</i>	<i>F</i>	<i>P</i>
		<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>				
Non-participants in organized sports clubs (n = 7025)									
Finland									
11-year-olds	Boys	2.23	0.13	2.67	0.11	1	5496.79	6.57	0.010
	Girls	1.74	0.12	2.35	0.10	1	3705.88	16.53	<0.001
13-year-olds	Boys	2.40	0.14	2.33	0.10	1	4354.57	0.15	0.701
	Girls	1.77	0.13	2.22	0.10	1	3802.38	7.47	0.006
15-year-olds	Boys	2.13	0.13	2.55	0.09	1	3519.73	7.80	0.005
	Girls	1.53	0.12	2.49	0.09	1	2994.47	43.56	<0.001
Norway									
11-year-olds	Boys	2.41	0.14	2.67	0.19	1	10305.13	1.22	0.269
	Girls	1.90	0.14	2.32	0.16	1	8741.30	4.01	0.045
13-year-olds	Boys	2.14	0.14	2.32	0.18	1	7515.48	0.64	0.423
	Girls	1.89	0.13	2.20	0.16	1	5819.19	2.35	0.126
15-year-olds	Boys	1.92	0.14	2.39	0.16	1	6269.18	5.03	0.025
	Girls	1.93	0.13	2.31	0.14	1	4963.34	4.09	0.043
Participants in organized sports clubs (n = 7735)									
Finland									
11-year-olds	Boys	3.67	0.13	3.93	0.09	1	4188.92	2.78	0.095
	Girls	2.92	0.15	3.84	0.09	1	5405.56	26.61	<0.001
13-year-olds	Boys	4.39	0.15	4.66	0.10	1	5111.43	2.12	0.145
	Girls	3.35	0.17	4.36	0.10	1	6062.40	25.61	<0.001
15-year-olds	Boys	4.82	0.15	4.82	0.12	1	6173.68	0.00	0.992
	Girls	3.84	0.18	4.91	0.11	1	7108.10	25.74	<0.001
Norway									
11-year-olds	Boys	3.62	0.10	4.33	0.10	1	3484.50	24.86	<0.001
	Girls	2.97	0.11	3.95	0.10	1	3993.29	40.83	<0.001
13-year-olds	Boys	3.47	0.11	4.43	0.13	1	3800.69	31.63	<0.001
	Girls	3.24	0.11	4.05	0.13	1	3423.20	23.21	<0.001
15-year-olds	Boys	3.84	0.11	4.92	0.15	1	4410.53	35.24	<0.001
	Girls	3.31	0.12	4.59	0.15	1	4765.40	44.12	<0.001

in earlier dropout. Previous research has described similar changes, suggesting that involvement in organized sports has trickled down to the youngest adolescents.²¹ However, although the observed changes are statistically significant, the effect sizes related to these changes are small to medium.

The age-related pattern of increased involvement among 11-year-olds and decreased involvement among 15-year-olds might also be linked to the introduction of the Provision on Children's Sports in Norway. The provision might have contributed to a greater recruitment of younger children with its focus on mastery and play, and not skills. However, from the age of 13 years, the Norwegian guidelines for youth sports allow for more competition and increasing specialization,

which can be perceived as undesirable for the adolescents.²⁵ Such negative reactions to increased competitiveness were observed in a Norwegian study based on self-reported data from 14-16-year-olds in 2006. The study revealed that the most common reasons why participants had left sports clubs were that the demands for improved achievement were too high.²⁷ In a similar vein, Crane and Temple's³³ systematic review identified participants' perceptions of their physical or sport competence as a prominent reason for dropout from organized sports.

While participation among boys in Finland and Norway seem to change in a similar way, the highest increase was among Finnish girls, as reflected in an increase of 20 percentage

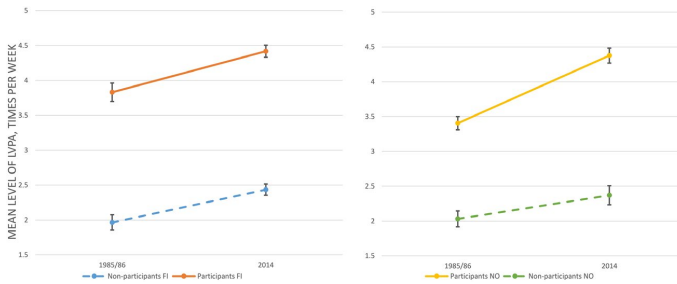


FIGURE 1 Mean level of weekly LVPA for participants and non-participants in organized sports in 1985 and 2014 in Finland (left) and Norway (right)

points among 11-year-olds. This finding support similar results from other studies in Finland on girls' participation in sports clubs.^{11,24} The observed increase may be explained by the development within sports clubs in Finland. During the last 20-30 years, a wider variation of different activities that attract girls more than boys, such as dancing and cheerleading, have been made available within sports clubs.¹¹ It is important to notice that the significant increase in participation among Finnish girls comes from a low proportion of participants in 1985/1986, thereby having greater potential for an increase.

At both time points, the proportion of participants in organized sports clubs were higher in Norway compared to Finland. Previous research has pointed toward favorable socioeconomic conditions, high availability for sporting facilities, a well-established voluntary sports club sector, high levels of parental involvement, and growth in individual and social prosperity during the 1990s as reasons for the high levels and increases in participation in Norway.³⁴

The present findings suggest that self-reported LVPA among Finnish and Norwegian children and adolescents increased from 1985/1986 to 2014. Similar changes in the prevalence of LVPA from 2002 to 2014 were found among 15-year-olds in several other countries within the HBSC study.³ Moreover, these findings are consistent with previous reviews,^{4,5} and contradict the popular notion that children and adolescents' level of physical activity has declined over the past decades.

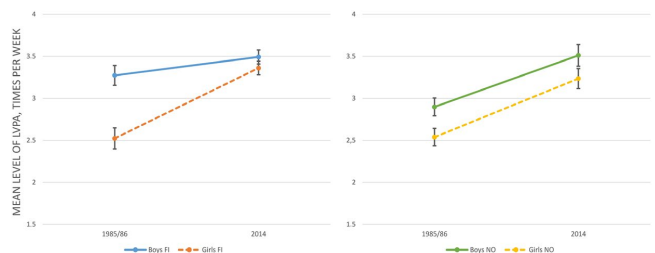
Participants in organized sports clubs reported higher level of LVPA compared to non-participants at both time points. Several other studies have also documented a positive relationship between sport participation and VPA.^{16-18,35} The difference in level of LVPA between participants

and non-participants was higher in 2014 than in 1985/1986, shown in Figure 1. Possibly, the larger difference in 2014 points to changes within organized sport as a driving force for changes in overall LVPA. For all age groups, the level of commitment when participating in organized sports clubs might have increased, resulting in that more of the LVPA among children and adolescents is carried out in organized structures such as sports clubs. Research on secular changes in Norway from 1992 to 2010 found an increase in the reported number of times per week adolescents participated in organized sports.²⁵ Increased commitment and frequency might imply that the importance of participation in organized sports clubs for higher levels of LVPA has increased from 1985/1986 to 2014. Macro-environmental and demographic changes such as less space for spontaneous PA and increased preferences for safe and structured activities might have influenced children and adolescents PA behavior. In addition, increased parental involvement in their children's participation in sports, which is considered a generational change,³⁷ may have led to the observed increase in the association between participation and level of LVPA among children and adolescents as parents encourage and arrange for participation in sports clubs.

For the 15-year-olds in Norway, the change can be related to selection as we found a decrease in the proportion of participants in organized sports clubs in this age group. Those 15-year-olds who participate in organized sports clubs might invest more time and energy in activities related to this sport, resulting in a stronger association between participation in organized sports clubs and LVPA in 2014 compared to 1985/1986.

In Finland, a substantial increase in LVPA was observed also among non-participating girls, perhaps related to secular

FIGURE 2 Mean level of weekly LVPA for boys and girls in 1985 and 2014 in Finland (left) and Norway (right)



changes in the engagement in keep-fit activities outside organized structures or within new arenas, like commercial fitness centers. Previous research on secular changes from 1974 to 1995 in Sweden found a decrease in participation in traditional team sports and that activities outside organized sports clubs had increased in popularity. Increased focus on a healthy lifestyle and participation in keep-fit activities was proposed as a possible contribution to increased levels of physical activity outside organized structures.²³ As we do not measure how much of the self-reported LVPA that is related to activities within organized sports clubs, it is possible that the increased focus on a healthy lifestyle, keep-fit activities, and informal sports^{23,28} also contributed to the increase in LVPA among those who participate in organized sports clubs.

This study is not without limitations. As the study is cross-sectional, the causal direction of the relationship between participation in organized sports clubs and frequency of LVPA cannot be established. Participation in organized sports clubs can lead to higher levels of LVPA, at the same time as high levels of LVPA can lead to participation in organized sports clubs. Further, self-reported activity might be affected by the respondents' desire to provide socially desirable answers, or by recall bias.³⁸ Several of these biases could be avoided through objective measures of physical activity. However, it is difficult to find comparable objective measures, mainly because our data go back to 1985, a time when objective measures of physical activity were not commonly used within this research field. In Norway, the comparability of the data from 1985/1986 and 2014 might have been affected by seasonal variance, as the data collection in 1985 was mid-winter, while in 2014 it was done from early spring to mid-winter. However, we did not find significant differences between the two subsamples from spring and mid-winter in 2014 (results not shown). A Norwegian study using objective measurements concluded that seasonal variation influenced children more than adolescents, as they found no association between season and PA level among 15-year-olds although this was the case among 9-year-olds.³⁹ It is worth noticing that the geographical distribution of the population in Norway might result in seasonal variances because of the variation in climate from north to south. The variation in measurement point would however been more relevant if the measures used were related to type of activity and not frequency of LVPA. The main strengths of this study are the relatively large and population-based samples and the comparable and repeated measurements from Finland and Norway following the HBSC protocol both time points.

5 | PERSPECTIVES

Participation in organized sports clubs by children and adolescents is a common and popular leisure-time

activity. Increased recruitment into organized sports has the potential to benefit the lives of children and adolescents in terms of positive youth development and both psychological and social health and gives opportunities to develop positive health behaviors that endure across the lifespan.

Our results support positive development of improved recruitment into organized sports among 11-year-olds in both countries. However, we suggest that more attention should be given to the possible negative development of reduced involvement among older adolescents and to the increased difference in LVPA between participants and non-participants in organized sports in Norway. Organized sports clubs should continue to focus on preventing drop-out, that is, keeping more adolescents involved in this positive setting for LVPA. In Finland, the positive development in both participation in organized sports clubs and level of LVPA among girls should be further investigated and continuously promoted.

Results of previous research on secular changes and trends in PA among children and adolescents has been inconsistent, and the need for studying specific domains within PA has been addressed.⁵ The overall levels of LVPA increased from 1985 to 2014 in this sample of 11 to 15-year-olds in Finland and Norway. However, the development differed between different subgroups. This adds to the importance of studying the role of participation and gender differences to better understand secular PA changes in a modern society.

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	Kallestad, Jan Helge, Dr. philos.	Teachers, schools and implementation of the Olweus Bullying Prevention Program.
H	Ofte, Sonja Helgesen, Dr. psychol.	Right-left discrimination in adults and children.
	Netland, Marit, Dr. psychol.	Exposure to political violence. The need to estimate our estimations.
	Diseth, Åge, Dr. psychol.	Approaches to learning: Validity and prediction of academic performance.
	Bjuland, Raymond, Dr. philos.	Problem solving in geometry. Reasoning processes of student teachers working in small groups: A dialogical approach.
2003 V	Arefjord, Kjersti, Dr. psychol.	After the myocardial infarction – the wives' view. Short- and long-term adjustment in wives of myocardial infarction patients.
	Ingjaldsson, Jón Þorvaldur, Dr. psychol.	Unconscious Processes and Vagal Activity in Alcohol Dependency.
	Holden, Børge, Dr. philos.	Følger av atferdsanalytiske forklaringer for atferdsanalysens tilnærming til utforming av behandling.
	Holsen, Ingrid, Dr. philos.	Depressed mood from adolescence to 'emerging adulthood'. Course and longitudinal influences of body image and parent-adolescent relationship.
	Hammar, Åsa Karin, Dr. psychol.	Major depression and cognitive dysfunction- An experimental study of the cognitive effort hypothesis.
	Sprugevica, Ieva, Dr. philos.	The impact of enabling skills on early reading acquisition.
	Gabrielsen, Egil, Dr. philos.	LESE FOR LIVET. Lesekompetansen i den norske voksenbefolkningen sett i lys av visjonen om en enhetsskole.
H	Hansen, Anita Lill, Dr. psychol.	The influence of heart rate variability in the regulation of attentional and memory processes.
	Dyregrov, Kari, Dr. philos.	The loss of child by suicide, SIDS, and accidents: Consequences, needs and provisions of help.
2004 V	Torsheim, Torbjørn, Dr. psychol.	Student role strain and subjective health complaints: Individual, contextual, and longitudinal perspectives.
	Haugland, Bente Storm Mowatt Dr. psychol.	Parental alcohol abuse. Family functioning and child adjustment.

	Milde, Anne Marita, Dr. psychol.	Ulcerative colitis and the role of stress. Animal studies of psychobiological factors in relationship to experimentally induced colitis.
	Stornes, Tor, Dr. philos.	Socio-moral behaviour in sport. An investigation of perceptions of sportspersonship in handball related to important factors of socio-moral influence.
	Mæhle, Magne, Dr. philos.	Re-inventing the child in family therapy: An investigation of the relevance and applicability of theory and research in child development for family therapy involving children.
	Kobbeltvedt, Therese, Dr. psychol.	Risk and feelings: A field approach.
2004	Thomsen, Tormod, Dr. psychol.	Localization of attention in the brain.
H	Løberg, Else-Marie, Dr. psychol.	Functional laterality and attention modulation in schizophrenia: Effects of clinical variables.
	Kyrkjebø, Jane Mikkelsen, Dr. philos.	Learning to improve: Integrating continuous quality improvement learning into nursing education.
	Laumann, Karin, Dr. psychol.	Restorative and stress-reducing effects of natural environments: Experiential, behavioural and cardiovascular indices.
	Holgensen, Helge, PhD	Mellom oss - Essay i relasjonell psykoanalyse.
2005	Hetland, Hilde, Dr. psychol.	Leading to the extraordinary? Antecedents and outcomes of transformational leadership.
V	Iversen, Anette Christine, Dr. philos.	Social differences in health behaviour: the motivational role of perceived control and coping.
2005	Mathisen, Gro Ellen, PhD	Climates for creativity and innovation: Definitions, measurement, predictors and consequences.
H	Sævi, Tone, Dr. philos.	Seeing disability pedagogically – The lived experience of disability in the pedagogical encounter.
	Wiium, Nora, PhD	Intrapersonal factors, family and school norms: combined and interactive influence on adolescent smoking behaviour.
	Kanagaratnam, Pushpa, PhD	Subjective and objective correlates of Posttraumatic Stress in immigrants/refugees exposed to political violence.
	Larsen, Torill M. B. , PhD	Evaluating principals` and teachers` implementation of Second Step. A case study of four Norwegian primary schools.
	Bancila, Delia, PhD	Psychosocial stress and distress among Romanian adolescents and adults.
2006	Hillestad, Torgeir Martin, Dr. philos.	Normalitet og avvik. Forutsetninger for et objektivt psykopatologisk avviksbegrep. En psykologisk, sosial, erkjennelsesteoretisk og teorihistorisk framstilling.
V	Nordanger, Dag Øystein, Dr. psychol.	Psychosocial discourses and responses to political violence in post-war Tigray, Ethiopia.

	Rimol, Lars Morten, PhD	Behavioral and fMRI studies of auditory laterality and speech sound processing.
	Krumsvik, Rune Johan, Dr. philos.	ICT in the school. ICT-initiated school development in lower secondary school.
	Norman, Elisabeth, Dr. psychol.	Gut feelings and unconscious thought: An exploration of fringe consciousness in implicit cognition.
	Israel, K Pravin, Dr. psychol.	Parent involvement in the mental health care of children and adolescents. Empirical studies from clinical care setting.
	Glasø, Lars, PhD	Affects and emotional regulation in leader-subordinate relationships.
	Knutsen, Ketil, Dr. philos.	HISTORIER UNGDOM LEVER – En studie av hvordan ungdommer bruker historie for å gjøre livet meningsfullt.
	Matthiesen, Stig Berge, PhD	Bullying at work. Antecedents and outcomes.
2006	Gramstad, Arne, PhD	Neuropsychological assessment of cognitive and emotional functioning in patients with epilepsy.
H	Bendixen, Mons, PhD	Antisocial behaviour in early adolescence: Methodological and substantive issues.
	Mrumbi, Khalifa Maulid, PhD	Parental illness and loss to HIV/AIDS as experienced by AIDS orphans aged between 12-17 years from Temeke District, Dar es Salaam, Tanzania: A study of the children's psychosocial health and coping responses.
	Hetland, Jørn, Dr. psychol.	The nature of subjective health complaints in adolescence: Dimensionality, stability, and psychosocial predictors
	Kakoko, Deodatus Conatus Vitalis, PhD	Voluntary HIV counselling and testing service uptake among primary school teachers in Mwanza, Tanzania: assessment of socio-demographic, psychosocial and socio-cognitive aspects
	Mykletun, Arnstein, Dr. psychol.	Mortality and work-related disability as long-term consequences of anxiety and depression: Historical cohort designs based on the HUNT-2 study
	Sivertsen, Børge, PhD	Insomnia in older adults. Consequences, assessment and treatment.
2007	Singhammer, John, Dr. philos.	Social conditions from before birth to early adulthood – the influence on health and health behaviour
V	Janvin, Carmen Ani Cristea, PhD	Cognitive impairment in patients with Parkinson's disease: profiles and implications for prognosis
	Braarud, Hanne Cecilie, Dr. psychol.	Infant regulation of distress: A longitudinal study of transactions between mothers and infants
	Tveito, Torill Helene, PhD	Sick Leave and Subjective Health Complaints
	Magnussen, Liv Heide, PhD	Returning disability pensioners with back pain to work

	Thuen, Elin Marie, Dr.philos.	Learning environment, students' coping styles and emotional and behavioural problems. A study of Norwegian secondary school students.
	Solberg, Ole Asbjørn, PhD	Peacekeeping warriors – A longitudinal study of Norwegian peacekeepers in Kosovo
2007	Søreide, Gunn Elisabeth, Dr.philos.	Narrative construction of teacher identity
H	Svensen, Erling, PhD	WORK & HEALTH. Cognitive Activation Theory of Stress applied in an organisational setting.
	Øverland, Simon Nygaard, PhD	Mental health and impairment in disability benefits. Studies applying linkages between health surveys and administrative registries.
	Eichele, Tom, PhD	Electrophysiological and Hemodynamic Correlates of Expectancy in Target Processing
	Børhaug, Kjetil, Dr.philos.	Oppseding til demokrati. Ein studie av politisk oppseding i norsk skule.
	Eikeland, Thorleif, Dr.philos.	Om å vokse opp på barnehjem og på sykehus. En undersøkelse av barnehjemsbarns opplevelser på barnehjem sammenholdt med sanatoriebarns beskrivelse av langvarige sykehusopphold – og et forsøk på forklaring.
	Wadel, Carl Cato, Dr.philos.	Medarbeidersamhandling og medarbeiderledelse i en lagbasert organisasjon
	Vinje, Hege Forbech, PhD	Thriving despite adversity: Job engagement and self-care among community nurses
	Noort, Maurits van den, PhD	Working memory capacity and foreign language acquisition
2008	Breivik, Kyrre, Dr.psychol.	The Adjustment of Children and Adolescents in Different Post-Divorce Family Structures. A Norwegian Study of Risks and Mechanisms.
V	Johnsen, Grethe E., PhD	Memory impairment in patients with posttraumatic stress disorder
	Sætrevik, Bjørn, PhD	Cognitive Control in Auditory Processing
	Carvalhosa, Susana Fonseca, PhD	Prevention of bullying in schools: an ecological model
2008	Brønnick, Kolbjørn Selvåg	Attentional dysfunction in dementia associated with Parkinson's disease.
H	Posserud, Maja-Britt Rocio	Epidemiology of autism spectrum disorders
	Haug, Ellen	Multilevel correlates of physical activity in the school setting
	Skjerve, Arvid	Assessing mild dementia – a study of brief cognitive tests.

	Kjønniksen, Lise	The association between adolescent experiences in physical activity and leisure time physical activity in adulthood: a ten year longitudinal study
	Gundersen, Hilde	The effects of alcohol and expectancy on brain function
	Omvik, Siri	Insomnia – a night and day problem
2009 V	Molde, Helge	Pathological gambling: prevalence, mechanisms and treatment outcome.
	Foss, Else	Den omsorgsfulle væremåte. En studie av voksnes væremåte i forhold til barn i barnehagen.
	Westrheim, Kariane	Education in a Political Context: A study of Knowledge Processes and Learning Sites in the PKK.
	Wehling, Eike	Cognitive and olfactory changes in aging
	Wangberg, Silje C.	Internet based interventions to support health behaviours: The role of self-efficacy.
	Nielsen, Morten B.	Methodological issues in research on workplace bullying. Operationalisations, measurements and samples.
	Sandu, Anca Larisa	MRI measures of brain volume and cortical complexity in clinical groups and during development.
	Guribye, Eugene	Refugees and mental health interventions
	Sørensen, Lin	Emotional problems in inattentive children – effects on cognitive control functions.
	Tjomsland, Hege E.	Health promotion with teachers. Evaluation of the Norwegian Network of Health Promoting Schools: Quantitative and qualitative analyses of predisposing, reinforcing and enabling conditions related to teacher participation and program sustainability.
	Helleve, Ingrid	Productive interactions in ICT supported communities of learners
2009 H	Skorpen, Aina Øye, Christine	Dagliglivet i en psykiatrisk institusjon: En analyse av miljøterapeutiske praksiser
	Andreassen, Cecilie Schou	WORKAHOLISM – Antecedents and Outcomes
	Stang, Ingun	Being in the same boat: An empowerment intervention in breast cancer self-help groups
	Sequeira, Sarah Dorothee Dos Santos	The effects of background noise on asymmetrical speech perception
	Kleiven, Jo, dr.philos.	The Lillehammer scales: Measuring common motives for vacation and leisure behavior
	Jónsdóttir, Guðrún	Dubito ergo sum? Ni jenter møter naturfaglig kunnskap.
	Hove, Oddbjørn	Mental health disorders in adults with intellectual disabilities - Methods of assessment and prevalence of mental health disorders and problem behaviour
	Wageningen, Heidi Karin van	The role of glutamate on brain function

	Bjørkvik, Jofrid	God nok? Selvaktelse og interpersonlig fungering hos pasienter innen psykisk helsevern: Forholdet til diagnoser, symptomer og behandlingsutbytte
	Andersson, Martin	A study of attention control in children and elderly using a forced-attention dichotic listening paradigm
	Almås, Aslaug Grov	Teachers in the Digital Network Society: Visions and Realities. A study of teachers' experiences with the use of ICT in teaching and learning.
	Ulvik, Marit	Lærerutdanning som danning? Tre stemmer i diskusjonen
2010	Skår, Randi	Læringsprosesser i sykepleieres profesjonsutøvelse. En studie av sykepleieres læringserfaringer.
V	Roald, Knut	Kvalitetsvurdering som organisasjonslæring mellom skole og skoleeigar
	Lunde, Linn-Heidi	Chronic pain in older adults. Consequences, assessment and treatment.
	Danielsen, Anne Grete	Perceived psychosocial support, students' self-reported academic initiative and perceived life satisfaction
	Hysing, Mari	Mental health in children with chronic illness
	Olsen, Olav Kjellevod	Are good leaders moral leaders? The relationship between effective military operational leadership and morals
	Riese, Hanne	Friendship and learning. Entrepreneurship education through mini-enterprises.
	Holthe, Asle	Evaluating the implementation of the Norwegian guidelines for healthy school meals: A case study involving three secondary schools
H	Hauge, Lars Johan	Environmental antecedents of workplace bullying: A multi-design approach
	Bjørkelo, Brita	Whistleblowing at work: Antecedents and consequences
	Reme, Silje Endresen	Common Complaints – Common Cure? Psychiatric comorbidity and predictors of treatment outcome in low back pain and irritable bowel syndrome
	Helland, Wenche Andersen	Communication difficulties in children identified with psychiatric problems
	Beneventi, Harald	Neuronal correlates of working memory in dyslexia
	Thygesen, Elin	Subjective health and coping in care-dependent old persons living at home
	Aanes, Mette Marthinussen	Poor social relationships as a threat to belongingness needs. Interpersonal stress and subjective health complaints: Mediating and moderating factors.
	Anker, Morten Gustav	Client directed outcome informed couple therapy

	Bull, Torill	Combining employment and child care: The subjective well-being of single women in Scandinavia and in Southern Europe
	Viiig, Nina Grieg	Tilrettelegging for læreres deltakelse i helsefremmende arbeid. En kvalitativ og kvantitativ analyse av sammenhengen mellom organisatoriske forhold og læreres deltakelse i utvikling og implementering av Europeisk Nettverk av Helsefremmende Skoler i Norge
	Wolff, Katharina	To know or not to know? Attitudes towards receiving genetic information among patients and the general public.
	Ogden, Terje, dr.philos.	Familiebasert behandling av alvorlige atferdsproblemer blant barn og ungdom. Evaluering og implementering av evidensbaserte behandlingsprogrammer i Norge.
	Solberg, Mona Elin	Self-reported bullying and victimisation at school: Prevalence, overlap and psychosocial adjustment.
2011	Bye, Hege Høivik	Self-presentation in job interviews. Individual and cultural differences in applicant self-presentation during job interviews and hiring managers' evaluation
V	Notelaers, Guy	Workplace bullying. A risk control perspective.
	Moltu, Christian	Being a therapist in difficult therapeutic impasses. A hermeneutic phenomenological analysis of skilled psychotherapists' experiences, needs, and strategies in difficult therapies ending well.
	Myrseth, Helga	Pathological Gambling - Treatment and Personality Factors
	Schanche, Elisabeth	From self-criticism to self-compassion. An empirical investigation of hypothesized change processes in the Affect Phobia Treatment Model of short-term dynamic psychotherapy for patients with Cluster C personality disorders.
	Våpenstad, Eystein Victor, dr.philos.	Det tempererte nærvær. En teoretisk undersøkelse av psykoterapeutens subjektivitet i psykoanalyse og psykoanalytisk psykoterapi.
	Haukebø, Kristin	Cognitive, behavioral and neural correlates of dental and intra-oral injection phobia. Results from one treatment and one fMRI study of randomized, controlled design.
	Harris, Anette	Adaptation and health in extreme and isolated environments. From 78°N to 75°S.
	Bjørknes, Ragnhild	Parent Management Training-Oregon Model: intervention effects on maternal practice and child behavior in ethnic minority families
	Mamen, Asgeir	Aspects of using physical training in patients with substance dependence and additional mental distress
	Espevik, Roar	Expert teams: Do shared mental models of team members make a difference
	Haara, Frode Olav	Unveiling teachers' reasons for choosing practical activities in mathematics teaching

2011 H	Hauge, Hans Abraham	How can employee empowerment be made conducive to both employee health and organisation performance? An empirical investigation of a tailor-made approach to organisation learning in a municipal public service organisation.
	Melkevik, Ole Rogstad	Screen-based sedentary behaviours: pastimes for the poor, inactive and overweight? A cross-national survey of children and adolescents in 39 countries.
	Vøllestad, Jon	Mindfulness-based treatment for anxiety disorders. A quantitative review of the evidence, results from a randomized controlled trial, and a qualitative exploration of patient experiences.
	Tolo, Astrid	Hvordan blir lærerkompetanse konstruert? En kvalitativ studie av PPU-studenters kunnskapsutvikling.
	Saus, Evelyn-Rose	Training effectiveness: Situation awareness training in simulators
	Nordgreen, Tine	Internet-based self-help for social anxiety disorder and panic disorder. Factors associated with effect and use of self-help.
	Munkvold, Linda Helen	Oppositional Defiant Disorder: Informant discrepancies, gender differences, co-occurring mental health problems and neurocognitive function.
	Christiansen, Øivin	Når barn plasseres utenfor hjemmet: beslutninger, forløp og relasjoner. Under barnevernets (ved)tak.
	Brunborg, Geir Scott	Conditionability and Reinforcement Sensitivity in Gambling Behaviour
	Hystad, Sigurd William	Measuring Psychological Resiliency: Validation of an Adapted Norwegian Hardiness Scale
2012 V	Rones, Dag	Hvorfor bli lærer? Motivasjon for utdanning og utøving.
	Fjermestad, Krister Westlye	The therapeutic alliance in cognitive behavioural therapy for youth anxiety disorders
	Jenssen, Eirik Sørnes	Tilpasset opplæring i norsk skole: politikeres, skolelederes og læreres handlingsvalg
	Saksvik-Lehouillier, Ingvild	Shift work tolerance and adaptation to shift work among offshore workers and nurses
	Johansen, Venke Frederike	Når det intime blir offentlig. Om kvinners åpenhet om brystkreft og om markedsføring av brystkreftsaken.
	Herheim, Rune	Pupils collaborating in pairs at a computer in mathematics learning: investigating verbal communication patterns and qualities
	Vie, Tina Løkke	Cognitive appraisal, emotions and subjective health complaints among victims of workplace bullying: A stress-theoretical approach
	Jones, Lise Øen	Effects of reading skills, spelling skills and accompanying efficacy beliefs on participation in education. A study in Norwegian prisons.

2012 H	Danielsen, Yngvild Sørebo	Childhood obesity – characteristics and treatment. Psychological perspectives.
	Horverak, Jøri Gytre	Sense or sensibility in hiring processes. Interviewee and interviewer characteristics as antecedents of immigrant applicants' employment probabilities. An experimental approach.
	Jøsendal, Ola	Development and evaluation of BE smokeFREE, a school-based smoking prevention program
	Osnes, Berge	Temporal and Posterior Frontal Involvement in Auditory Speech Perception
	Drageset, Sigrunn	Psychological distress, coping and social support in the diagnostic and preoperative phase of breast cancer
	Aasland, Merethe Schanke	Destructive leadership: Conceptualization, measurement, prevalence and outcomes
	Bakibinga, Pauline	The experience of job engagement and self-care among Ugandan nurses and midwives
	Skogen, Jens Christoffer	Foetal and early origins of old age health. Linkage between birth records and the old age cohort of the Hordaland Health Study (HUSK)
	Leveresen, Ingrid	Adolescents' leisure activity participation and their life satisfaction: The role of demographic characteristics and psychological processes
	Hanss, Daniel	Explaining sustainable consumption: Findings from cross-sectional and intervention approaches
Rød, Per Arne	Barn i klem mellom foreldrekonflikter og samfunnmessig beskyttelse	
2013 V	Mentzoni, Rune Aune	Structural Characteristics in Gambling
	Knudsen, Ann Kristin	Long-term sickness absence and disability pension award as consequences of common mental disorders. Epidemiological studies using a population-based health survey and official ill health benefit registries.
	Strand, Mari	Emotional information processing in recurrent MDD
	Veseth, Marius	Recovery in bipolar disorder. A reflexive-collaborative exploration of the lived experiences of healing and growth when battling a severe mental illness
	Mæland, Silje	Sick leave for patients with severe subjective health complaints. Challenges in general practice.
	Mjaaland, Thera	At the frontiers of change? Women and girls' pursuit of education in north-western Tigray, Ethiopia
	Odéen, Magnus	Coping at work. The role of knowledge and coping expectancies in health and sick leave.
	Hynninen, Kia Minna Johanna	Anxiety, depression and sleep disturbance in chronic obstructive pulmonary disease (COPD). Associations, prevalence and effect of psychological treatment.
Flo, Elisabeth	Sleep and health in shift working nurses	

	Aasen, Elin Margrethe	From paternalism to patient participation? The older patients undergoing hemodialysis, their next of kin and the nurses: a discursive perspective on perception of patient participation in dialysis units
	Ekornås, Belinda	Emotional and Behavioural Problems in Children: Self-perception, peer relationships, and motor abilities
	Corbin, J. Hope	North-South Partnerships for Health: Key Factors for Partnership Success from the Perspective of the KIWAKKUKI
	Birkeland, Marianne Skogbrott	Development of global self-esteem: The transition from adolescence to adulthood
2013 H	Gianella-Malca, Camila	Challenges in Implementing the Colombian Constitutional Court's Health-Care System Ruling of 2008
	Hovland, Anders	Panic disorder – Treatment outcomes and psychophysiological concomitants
	Mortensen, Øystein	The transition to parenthood – Couple relationships put to the test
	Årdal, Guro	Major Depressive Disorder – a Ten Year Follow-up Study. Inhibition, Information Processing and Health Related Quality of Life
	Johansen, Rino Bandlitz	The impact of military identity on performance in the Norwegian armed forces
	Bøe, Tormod	Socioeconomic Status and Mental Health in Children and Adolescents
2014 V	Nordmo, Ivar	Gjennom nåløyet – studenters læringserfaringer i psykologutdanningen
	Dovran, Anders	Childhood Trauma and Mental Health Problems in Adult Life
	Hegelstad, Wenche ten Velden	Early Detection and Intervention in Psychosis: A Long-Term Perspective
	Urheim, Ragnar	Forståelse av pasientaggresjon og forklaringer på nedgang i voldsrater ved Regional sikkerhetsavdeling, Sandviken sykehus
	Kinn, Liv Grethe	Round-Trips to Work. Qualitative studies of how persons with severe mental illness experience work integration.
	Rød, Anne Marie Kinn	Consequences of social defeat stress for behaviour and sleep. Short-term and long-term assessments in rats.
	Nygård, Merethe	Schizophrenia – Cognitive Function, Brain Abnormalities, and Cannabis Use
	Tjora, Tore	Smoking from adolescence through adulthood: the role of family, friends, depression and socioeconomic status. Predictors of smoking from age 13 to 30 in the "The Norwegian Longitudinal Health Behaviour Study" (NLHB)
	Vangsnes, Vigdis	The Dramaturgy and Didactics of Computer Gaming. A Study of a Medium in the Educational Context of Kindergartens.

	Nordahl, Kristin Berg	Early Father-Child Interaction in a Father-Friendly Context: Gender Differences, Child Outcomes, and Protective Factors related to Fathers' Parenting Behaviors with One-year-olds
2014 H	Sandvik, Asle Makoto	Psychopathy – the heterogeneity of the construct
	Skotheim, Siv	Maternal emotional distress and early mother-infant interaction: Psychological, social and nutritional contributions
	Halleland, Helene Barone	Executive Functioning in adult Attention Deficit Hyperactivity Disorder (ADHD). From basic mechanisms to functional outcome.
	Halvorsen, Kirsti Vindal	Partnerskap i lærerutdanning, sett fra et økologisk perspektiv
	Solbue, Vibeke	Dialogen som visker ut kategorier. En studie av hvilke erfaringer innvandrerdommer og norskfødte med innvandrereforeldre har med videregående skole. Hva forteller ungdommenes erfaringer om videregående skoles håndtering av etniske ulikheter?
	Kvalevaag, Anne Lise	Fathers' mental health and child development. The predictive value of fathers' psychological distress during pregnancy for the social, emotional and behavioural development of their children
	Sandal, Ann Karin	Ungdom og utdanningsval. Om elevar sine opplevingar av val og overgangsprossessar.
	Haug, Thomas	Predictors and moderators of treatment outcome from high- and low-intensity cognitive behavioral therapy for anxiety disorders. Association between patient and process factors, and the outcome from guided self-help, stepped care, and face-to-face cognitive behavioral therapy.
	Sjølie, Hege	Experiences of Members of a Crisis Resolution Home Treatment Team. Personal history, professional role and emotional support in a CRHT team.
	Falkenberg, Liv Eggset	Neuronal underpinnings of healthy and dysfunctional cognitive control
Mrdalj, Jelena	The early life condition. Importance for sleep, circadian rhythmicity, behaviour and response to later life challenges	
Hesjedal, Elisabeth	Tverrprofesjonelt samarbeid mellom skule og barnevern: Kva kan støtte utsette barn og unge?	
2015 V	Hauken, May Aasebø	« <i>The cancer treatment was only half the work!</i> » A Mixed-Method Study of Rehabilitation among Young Adult Cancer Survivors
	Ryland, Hilde Katrin	Social functioning and mental health in children: the influence of chronic illness and intellectual function
	Rønsen, Anne Kristin	Vurdering som profesjonskompetanse. Refleksjonsbasert utvikling av læreres kompetanse i formativ vurdering

	Hoff, Helge Andreas	Thinking about Symptoms of Psychopathy in Norway: Content Validation of the Comprehensive Assessment of Psychopathic Personality (CAPP) Model in a Norwegian Setting
	Schmid, Marit Therese	Executive Functioning in recurrent- and first episode Major Depressive Disorder. Longitudinal studies
	Sand, Liv	Body Image Distortion and Eating Disturbances in Children and Adolescents
	Matanda, Dennis Juma	Child physical growth and care practices in Kenya: Evidence from Demographic and Health Surveys
	Amugsi, Dickson Abanimi	Child care practices, resources for care, and nutritional outcomes in Ghana: Findings from Demographic and Health Surveys
	Jakobsen, Hilde	The good beating: Social norms supporting men's partner violence in Tanzania
	Sagoe, Dominic	Nonmedical anabolic-androgenic steroid use: Prevalence, attitudes, and social perception
	Eide, Helene Marie Kjærgård	Narrating the relationship between leadership and learning outcomes. A study of public narratives in the Norwegian educational sector.
2015	Wubs, Annegreet Gera	Intimate partner violence among adolescents in South Africa and Tanzania
H	Hjelmervik, Helene Susanne	Sex and sex-hormonal effects on brain organization of fronto-parietal networks
	Dahl, Berit Misund	The meaning of professional identity in public health nursing
	Røykenes, Kari	Testangst hos sykepleierstudenter: «Alternativ behandling»
	Bless, Josef Johann	The smartphone as a research tool in psychology. Assessment of language lateralization and training of auditory attention.
	Løvvik, Camilla Margrethe Sigvaldsen	Common mental disorders and work participation – the role of return-to-work expectations
	Lehmann, Stine	Mental Disorders in Foster Children: A Study of Prevalence, Comorbidity, and Risk Factors
	Knapstad, Marit	Psychological factors in long-term sickness absence: the role of shame and social support. Epidemiological studies based on the Health Assets Project.
2016	Kvestad, Ingrid	Biological risks and neurodevelopment in young North Indian children
V	Sælør, Knut Tore	Hinderløyper, halmstrå og hengende snører. En kvalitativ studie av håp innenfor psykisk helse- og rusfeltet.
	Mellingen, Sonja	Alkoholbruk, partilfredshet og samlivsstatus. Før, inn i, og etter svangerskapet – korrelerer eller konsekvenser?
	Thun, Eirunn	Shift work: negative consequences and protective factors

	Hilt, Line Torbjørnsen	The borderlands of educational inclusion. Analyses of inclusion and exclusion processes for minority language students
	Havnen, Audun	Treatment of obsessive-compulsive disorder and the importance of assessing clinical effectiveness
	Slåtten, Hilde	Gay-related name-calling among young adolescents. Exploring the importance of the context.
	Ree, Eline	Staying at work. The role of expectancies and beliefs in health and workplace interventions.
	Morken, Frøydis	Reading and writing processing in dyslexia
2016	Løvoll, Helga Synnevåg	Inside the outdoor experience. On the distinction between pleasant and interesting feelings and their implication in the motivational process.
H	Hjeltnes, Aslak	Facing social fears: An investigation of mindfulness-based stress reduction for young adults with social anxiety disorder
	Øyeflaten, Irene Larsen	Long-term sick leave and work rehabilitation. Prognostic factors for return to work.
	Henriksen, Roger Ekeberg	Social relationships, stress and infection risk in mother and child
	Johnsen, Iren	«Only a friend» - The bereavement process of young adults who have lost a friend to a traumatic death. A mixed methods study.
	Helle, Siri	Cannabis use in non-affective psychoses: Relationship to age at onset, cognitive functioning and social cognition
	Glambek, Mats	Workplace bullying and expulsion in working life. A representative study addressing prospective associations and explanatory conditions.
	Oanes, Camilla Jensen	Tilbakemelding i terapi. På hvilke måter opplever terapeuter at tilbakemeldingsprosedyrer kan virke inn på terapeutiske praksiser?
	Reknes, Iselin	Exposure to workplace bullying among nurses: Health outcomes and individual coping
	Chimhutu, Victor	Results-Based Financing (RBF) in the health sector of a low-income country. From agenda setting to implementation: The case of Tanzania
	Ness, Ingunn Johanne	The Room of Opportunity. Understanding how knowledge and ideas are constructed in multidisciplinary groups working with developing innovative ideas.
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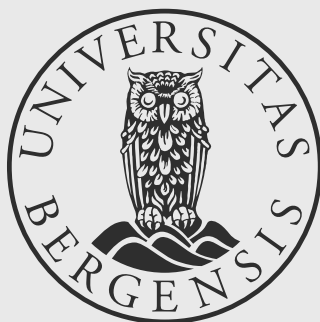
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