Author(s): Aaltonen, S.; Waller, K.; Vähä-Ypyä, H.; Rinne, J.; Sievänen, H.; Silventoinen, K.; Kaprio, J.; Kujala, U.M.

Title: Motives for physical activity in older men and women : A twin study using accelerometer-measured physical activity

Year: 2020

Version: Accepted version (Final draft)

Received: 27 November 2019 | Revised: 10 March 2020 | Accepted: 25 March 2020

DOI: 10.1111/sms.13673

ORIGINAL ARTICLE

WILEY

Motives for physical activity in older men and women: A twin study using accelerometer-measured physical activity

Sari Aaltonen[1] | Katja Waller[2] | Henri Vähä-Ypyä[3] | Juha Rinne[4] | Harri Sievänen[3] | Karri Silventoinen[5] | Jaakko Kaprio[1,6] | Urho M. Kujala[2]

[1]Institute for Molecular Medicine (FIMM), University of Helsinki, University of Helsinki, Helsinki, Finland

[2]Faculty of Sport and Health Sciences, University of Jyväskylä, University of Jyväskylä, Jyväskylä, Finland

[3]The UKK Institute for Health Promotion Research, Tampere, Finland

[4]Clinical Neurology, Turku PET Centre, Turku University Hospital, Turku, Finland

[5]Department of Social Research, University of Helsinki, University of Helsinki, Helsinki, Finland

[6]Department of Public Health, University of Helsinki, University of Helsinki, Helsinki, Finland

Correspondence
Sari Aaltonen Ph.D., Institute for Molecular Medicine (FIMM), University of Helsinki, P.O. Box 20 (Tukholmankatu 8), FIN-00014 University of Helsinki, Helsinki, Finland.
Email: sari.s.aaltonen@helsinki.fi

Funding information
Suomen Kulttuurirahasto; Juho Vainion Säätiö; The Academy of Finland, Grant/Award Number: and 312073 , 266592, 100499, 205585, 141054, 265240, 263278 and 264146; The Finnish Ministry of Education and Culture, Grant/Award Number: OKM/56/626/2013

Motives for physical activity may vary considerably by age, sex, and the level of physical activity. We aimed to examine motives for physical activity in older men and women with different physical activity levels as well as whether genetic and/or environmental factors explain those motives. Finnish twins (mean age 72.9 years, 262 full twin pairs) self-reported their motives for physical activity. Time spent on moderate-to-vigorous physical activity was monitored using a hip-worn accelerometer. Comparisons between the different physical activity groups of older twins (n = 764-791/motive dimension) were analyzed using the Wald test, and effect sizes were calculated as Cohen's *d*. Quantitative genetic modeling was used to estimate genetic and environmental contributions. For both sexes, the most frequently reported motives for physical activity were physical fitness, health maintenance, and psychological well-being. Conforming to others' expectations was more important for men than for women ($P < .001$, Cohen's $d = 0.38$), while appearance ($P = .001$ Cohen's $d = -0.24$) and psychological well-being ($P = .02$, Cohen's $d = -0.17$) were highlighted by women. Most of the motive dimensions differed significantly between the physically active and inactive individuals. It was estimated that 5%-42% of the variation in motives was contributed by genetic factors and 58%-95% by environmental factors. The result that environmental factors contribute in a great deal to motives indicates that interventions to motivate physically inactive older individuals to be physically active can be successful. However, personalized interventions are needed because sex and the level of physical activity were found to be associated with older individuals' motives for physical activity.

KEYWORDS
aged individuals, device-measured physical activity, exercise, motivation, twins

1 | INTRODUCTION

Motives for physical activity have been reported to be a crucial factor to understand individual differences in physical activity behavior.[1-3] Because the level of physical activity tends to progressively decrease with age[4] and because the proportion of the world's population over 60 years old will almost double within the next decades,[5] an increasing interest has arisen in investigating the motives for physical activity in the elderly population. It has been shown that older individuals are motivated by many general factors, such as health,[6] but motivational factors have also been revealed to vary with age.[7,8]

Two systematic reviews have evaluated motives for physical activity in old individuals, but they did not include meta-analyses to estimate pooled effect sizes.[9,10] Baert at al. (2011) [9] reported physical health as a major intrapersonal motive for physical activity in several studies in individuals in their 80s, followed by psychological benefits, such as enjoyment. Aspects related to social support were mentioned as one of the most important interpersonal motives for physical activity. The effect of professional advice was also mentioned in a few papers included in the review. In a review of reviews, Cavill & Foster (2018) [10] focused on motives to participate in strength and balance training activities in middle-aged and older individuals. Some of the motives found in this review were very general to all people for being physically active, such as psychological health benefits and social connection with others, while some motives were more specific to older individuals, such as improving the ability to complete daily activities and reducing the risk/fear of falling.

Despite the reasonable amount of studies on motives for physical activity in old age, fewer studies have examined whether sex differences exist in motives for physical activity in old age. Recently, van Uffelen and colleagues (2017) [6] focused on sex differences in motives for physical activity among individuals in their 60s. They found that the leading motives for physical activity were the same for both men and women, but differences were also found—older women were motivated more by appearance, the social aspect of physical activity and weight control than older men. Similarly, clear sex differences in motives for physical activity were observed among younger Malaysian adults from 20 to 64 years of age: Men were more motivated by competition and skill improvement, while women highlighted appearance and physical condition as their motivational factors.[11] However, two other studies, one of Finnish older individuals [12] and the other of Italian senior athletes,[13] did not find any sex differences in motives for physical activity.

Only a few studies have paid attention to how motives for physical activity differ by the level of physical activity among older individuals, although there is limited evidence that the current physical activity level explains the differences in motives even in older individuals.[1,3,14] When older physically active individuals have been compared to older physically inactive individuals, physical and psychological health,[1,3,14] fitness,[1,3,14] skill improvement,[3] and enjoyment[1,14] have been identified as major motives for physical activity among older physically active individuals. Active older individuals have also given higher ratings for stress management and social aspects as motivational factors compared to their inactive counterparts,[1,14] while physically inactive older individuals have highlighted other people's expectations[3] along with a need for purposeful and fun physical activity.[14]

The older the age-group, the more motives may differ compared to younger age-groups because older individuals may have specific needs that affect their daily lives and their chances to be physically active. However, according to our knowledge, there are no studies that have exclusively examined motives for physical activity among community-dwelling individuals aged 70 and over taking their sex and current level of physical activity into account. For this reason, the present study was launched. Most of the human behavioral traits are complex and multifactorial, with a likely contribution of many genes, each with small effect (ie, "polygenic traits"). These traits are not only affected by genetic factors, also environmental factors (ie, all the factors that make members of a monozygotic twin pair different from one another) play a role.[15] Nevertheless, the underlying roles of genetic and environmental factors behind individual differences in motives for physical activity have not previously been studied in older individuals, yet our previous study indicated the importance of these factors behind motives for physical activity among adults in their mid-30s.[16] In order to fill in this knowledge gap, it is important to estimate genetic and environmental variations of motives for physical activity in older individuals.

This study primarily aims to examine what the most frequently reported motives for physical activity among men and women over 70 years old are, and whether there are differences in motivational factors between the sexes and between the current levels of physical activity. Furthermore, we examine to what extent genetic and environmental factors contribute to motives for physical activity. Based on previous studies,[9,10] we hypothesize that both physical health and psychological health along with enjoyment of physical activity are the most important factors to induce both older men and women to be physically active. Further, based on previous findings,[6,11] we hypothesize that there are sex differences in motives for physical activity among older individuals—older women are assumed to be more likely motivated by their appearance and the social aspect of physical activity than older men. We also expect that those older individuals who are physically active report higher levels of intrinsic motives for physical activity (such as physical and psychological health and enjoyment of activity). Finally, we assume that genetic factors partly explain motives for physical activity in old age, as seen in younger ages. Based on our previous study,[16] we believe that the contribution of genetic factors will range between 10% and 55%—the motive dimensions of enjoyment and socializing being the highest.

2 | METHODS

2.1 | Participants

The participants for the MOBILETWIN study were drawn from the Older Finnish Twin Cohort study that was launched in 1974. It is a nationwide sample of all same-sex Finnish twin pairs born before 1958 with both co-twins alive in 1975. A total of 13 888 twin pairs have been identified.[17] Over the years, the twins have participated in three large mail surveys in 1975, 1981, and 1990. Zygosity (monozygotic (MZ), dizygotic (DZ), or uncertain) has been determined using a well-validated questionnaire.[18]

The MOBILETWIN study was conducted between 2014 and 2016, and only twin participants who were born between 1940 and 1944 were eligible for the study. Further, only the twin individuals who had responded to at least one of the first two mail surveys (1975 or 1981) were selected for the present study.[19] In total, 1632 twin individuals alive and contactable (ie, 816 complete same-sex twin pairs, out of which 256 were MZ, 490 DZ and 70 with unconfirmed zygosity) were invited to participate in a health and cognition telephone interview, use an accelerometer to monitor their physical activity behavior, and respond to a questionnaire related to physical functioning. The target group was a selected community-dwelling group of older individuals since those less healthy individuals living in nursing homes or long-term institutional care were not contactable. The details of the inclusion criteria have been published previously.[19]

In total, 1012 (62%) twin individuals participated in the telephone interview, 791 used the hip-worn accelerometer for the time required for the study, and the number of participants who reported their motives for physical activity ranged from 819 to 837 per motive dimension. Thus, we had data available on accelerometer-measured physical activity and motives for physical activity from 764 to 791 twin individuals per motive dimension (48%-51% women).

2.2 | Assessment of the motives for physical activity

To evaluate the older individuals' motives for physical activity, we used a questionnaire that was based on the Recreational Exercise Motivation Measure (REMM).[20] The original REMM measure was designed to assess adults' leisure-time physical activity motives, and it is based on the Self-Determination Theory.[21] This theory provides a strong foundation for understanding the goals and motives for behavior and focuses on the importance of intrinsic motives in driving human behavior.

The original version of the REMM measure consists of 73 items representing both intrinsic and extrinsic motives for physical activity. These 73 items form 8 dimensions of 8 to 13 items. In the MOBILETWIN study, these 8 dimensions were used to assess motives for physical activity due to the space restrictions of the mail survey questionnaire but also to make the questionnaire easier and faster for older individuals to complete. We used one general item per dimension to represent extensively the content of the dimension—this is, one item in the modified REMM equals to one dimension of the original REMM. Further, because the MOBILETWIN study focused on older individuals, we slightly adapted the contents of motivation measure to better meet the requirements of the older individuals (ie, to improve functional capacity that enables independent living) due to the fact that the original measure was designed to assess middle-aged adults' motives for physical activity. The dimension that is related to skill improvement and willingness to get better at an exercise (mastery) is very goal and vigorous physical activity-oriented. However, goal-oriented vigorous physical activity is very low in this age-group,[22,23] and in the present sample,[24] and, thus, this dimension was dropped from this study. Further, a dimension related to the competitive/ego-oriented side of the physical activity (ie, be fitter and/or look better than others) has also not been found as a major contributor to older individuals' physical activity behavior.[11] Due to this, we adapted this dimension as well to better fit the measure for older individuals. Obviously, these modifications may have consequences for the validity and the reliability of the measure.

The dimensions of the motivation measure in the MOBILETWIN study were (representative item shown in parentheses): (a) enjoyment ("have a good time and enjoy exercising"), (b) socializing ("be with friends and/or do activity with others"), (c) health ("be healthier"), (d) others' expectations ("conform to others' expectations"), (e) physical fitness ("be physically fit"), (f) psychological well-being ("improve psychological health/well-being"), and (g) appearance ("maintain/improve appearance"). The dimension of "enjoyment" represents intrinsic motives, whereas all the others represent aspects of extrinsic motivation. Participants were asked to rate each item on a 5-point Likert scale ranging from strongly disagree (a) to strongly agree (e). All the items were introduced by the sentence "I am physically active to…".

The developers of the REMM have validated the original REMM measure.[20] The Finnish version of the 73-item REMM has also been validated,[25] and the internal consistencies of the dimensions were found to be similar to those cited by the developers of the original measure.

2.3 | Assessment of physical activity

A light tri-axial hip-worn accelerometer was used to monitor the physical activity behavior of the older individuals (Hookie AM20, Traxmeet Ltd, Espoo).[19] The participants carried the devices for seven consecutive days during waking hours (except bathing, taking a shower, and swimming). The time criterion for adequate accelerometer data collection was that the accelerometers were carried for at least 10 hours per day for 4 days (non-wear time was defined as a sum of at least 30 minutes of consecutive zero acceleration), which was met by 791 twin individuals. Out of these individuals, 80% carried the devices for 7 days and 14% for 6 days. The average time the participants carried the devices was 14:01:44 h:min:s/d.

The analysis of raw acceleration data was based on algorithms that employ the mean amplitude deviation (MAD) of the raw acceleration signal and the angle for posture estimation (APE) of the body. Together, these metrics provide about 90% accuracy in assessing the intensity, volume and distribution of daily physical activity separating sedentary and stationary behaviors (ie, lying, sitting and standing) from any physical activity behavior.[26-28] For the analysis, MAD and APE values were determined for each 6 second epoch. The epoch-wise MAD values were expressed in metabolic equivalents (MET), and a 1-minute exponential moving average of the MET values was calculated to estimate incident energy consumption.

The validity of MAD values has been proved to be high [27]—a correlation between the MAD values of the resultant acceleration was found to be strong with directly measured incident oxygen uptake (VO_2) during walking or running at an indoor track ($r > .9$).[27] This strong association allowed for conversion of MAD values to incident energy consumption (MET value). According to recommended use,[29] the following cutoff points for different physical activities were set: 1.5-3 MET for light activities, 3-6 MET for moderate activities, and over 6 MET for vigorous activities, and corresponding mean daily total times were determined. Moderate-to-vigorous physical activity was constructed by summing up the time of moderate and vigorous physical activities. We assigned time spent on moderate-to-vigorous physical activity into quintiles, because the older participants in this study had difficulties to reach that level of physical activity. Moreover, the extremes of the distribution were used in the analyses to compare differences in motives for physical activity between moderately to vigorously physically inactive (being the lowest fifth) and active (being the highest fifth) older individuals.

2.4 | Statistical methods

We generated the distributions, means, standard deviations, standard errors, and/or confidence intervals of the basic characteristics and motives for physical activity in older men and women using Stata 14.1 software (StataCorp, College Station). The level of significance was set at $P < .05$ in all analyses.

The Wald test was used to assess whether motives for physical activity significantly differed between the quintiles of accelerometer-measured time spent on moderate-to-vigorous physical activity. Participants who had complete information on both variables were selected for analyses. A square-root-transformation for moderate-to-vigorous physical activity was applied, with a successful result, to correct problems with the normality assumption.

Because the participants of this study are twins, the observations and their error terms between members of a twin pair may be correlated. Therefore, we adjusted the standard errors for twin clustering. To assess the magnitude of the observed effect, we calculated Cohen's d (ie, the difference between means divided by the standard deviation). Because our analyses included older individuals with and without physician-diagnosed diseases, and because those physician-diagnosed diseases have been shown to reduce the level of physical activity in this study population,[30] we conducted a sensitivity analysis to examine whether these two groups of older individuals differed in terms of motivational factors.

Because we had information on both MZ and DZ twins, we were able to estimate genetic and environmental variations of motives for physical activity in older individuals by using information on their different genetic relatedness. MZ co-twins have virtually the same DNA sequence, while DZ co-twins share, on average, 50% of the genetic variation.[31] The similarities of MZ and DZ twins can be estimated by calculating intra-class correlation coefficients (ICC). Familial influences are inferred if the ICCs of DZ twin pairs (genetically full-siblings) differ from zero. If the correlations for MZ twins are significantly higher than those for DZ twins, genetic influences are indicated. If the correlations for DZ twins do not differ significantly from those for MZ twins but both differ from zero, then shared environmental influences are indicated. Shared environmental effects refer to all environmental influences that make co-twins alike (expected correlation 1.0 for both MZ and DZ twins). Unique environmental effects denote all environmental influences that make members of a twin pair unlike, since they are uncorrelated in both MZ and DZ twins, and include measurement error.

Quantitative genetic modeling was further used to examine the extent to which variation in motives for physical activity is accounted for by genetic and environmental influences. Based on the principles described above, we decomposed the trait variation in motive dimensions into three components: additive genetic variation, shared environmental variation, and unique environmental variation.[32] The proportion of variation accounted for by genetic influences is called heritability. High heritability estimates

TABLE 1 Characteristics of study participants at the time of accelerometer-based physical activity assessment

Characteristics	Men	Women	P-value
Age (years; mean (95% CI))	72.9 (72.8-73.0)	72.8 (72.7-72.9)	.20
	n = 413	n = 434	
BMI (kg/m^2; mean (95% CI))	26.2 (25.8-26.5)	26.1 (25.7-26.6)	.91
	n = 412	n = 427	
MVPA per day (minutes; mean (95% CI))	47.9 (46.1-49.8)	43.1 (41.4-44.7)	.005
	n = 385	n = 406	
Subjective health status			.40
Very good	11.1%	6.7%	
Good	46.8%	48.9%	
Fair	36.6%	41.0%	
Poor	5.3%	3.5%	
Very poor	0.2%	0%	
	n = 415	n = 434	
Subjective physical fitness			.51
Very good	18.3%	12.3%	
Good	46.6%	51.3%	
Fair	28.1%	32.5%	
Poor	6.5%	3.9%	
Very poor	0.5%	0%	
	n = 416	n = 431	
General physical activity level			<.001
Moderate/vigorous	19.9%	16.6%	
Light	68.1%	74.1%	
Sedentary	12.0%	9.4%	
Mainly in bed	0%	0%	
	n = 408	n = 428	
Diseases that hinder physical activity			.92
Yes	24.8%	24.5%	
No	75.2%	75.5%	
	n = 411	n = 428	
Walking 2 kilometers			.32
Manage to walk	80,0%	77.2%	
Manage to walk, but have minor difficulties	14.2%	15.4%	
Manage to walk, but have major difficulties	3.9%	4.9%	
Cannot walk without help	0.3%	0.5%	
Cannot walk even with help	1.7%	2.1%	
	n = 409	n = 429	

Abbreviations: BMI, body mass index; CI, confidence intervals; MVPA, moderate-to-vigorous physical activity.

indicate a minor role for environmental influences, whereas low heritability estimates are suggestive of a greater role for shared or unshared environmental influences, on the differences between individuals. Genetic modeling began by comparing different univariate models to select the best-fitting models to explain individual differences in motives for physical activity (Table S2). First, we determined whether shared environmental factors were present to explain the variation in motive dimensions. Univariate model-fitting results revealed that dropping the shared environmental path coefficients did not lead to a significant deterioration of model fit (*P*-values ranged from .16 to .96). Thus, the shared environmental components were dropped from the final models.

Furthermore, we tested whether there were differences in the absolute and relative genetic and environmental variances in motive dimensions between men and women. The results of absolute and relative genetic and environmental variances in motive dimensions did not show significant differences between men and women (*P*-values ranged from .92 to 1.00), except relative genetic and environmental variances in the motive dimensions of enjoyment ($P = .002$) and others' expectations ($P = .04$). However, the separate analyses for men and women showed insufficient statistical power regarding these motive dimensions; thus, both sexes were analyzed together in genetic modeling with regard to the motive dimensions of enjoyment and others' expectations.

Genetic modeling was carried out with OpenMx (version 2.0.1) software, which is a package for extended structural equation modeling on the R statistical platform. All the models were fitted to the raw data using maximum-likelihood algorithms (allowing inclusion also of twins without information on their co-twins) and treating unobserved data as missing-at-random.[33]

2.5 | Ethics of the study

The Ethics Committee of the Hospital District of Southwest Finland approved the MOBILETWIN study protocol on May 20, 2014. The participants provided written informed

TABLE 2 Distribution and means of motive dimensions among study participants

Motive dimension	Likert scale response options and assigned scores in parentheses					
	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)	Mean (95% CI)
Both men and women						
Enjoyment (n = 830)	22	29	135	319	325	4.08 (4.01-4.15)
Socializing (n = 825)	9	10	52	262	504	3.59 (3.51-3.66)
Health (n = 837)	9	10	52	262	504	4.48 (4.43-4.54)
Others' expectations (n = 819)	375	172	168	75	29	2.04 (1.96-2.12)
Physical fitness (n = 835)	5	4	48	229	549	4.57 (4.53-4.62)
Psychological well-being (n = 836)	14	6	66	287	463	4.41 (4.26-4.46)
Appearance (n = 830)	253	135	243	139	60	2.54 (2.45-2.63)
Men						
Enjoyment (n = 408)	14	16	63	154	161	4.06 (3.95-4.16)
Socializing (n = 407)	30	45	106	141	85	3.51 (3.39-3.62)
Health (n = 408)	4	5	30	134	235	4.45 (4.37-4.52)
Others' expectations (n = 401)	150	87	95	49	20	2.26 (2.14-2.38)
Physical fitness (n = 408)	3	2	20	120	263	4.56 (4.50-4.63)
Psychological well-being (n = 409)	9	3	39	147	211	4.34 (4.26-4.42)
Appearance (n = 408)	142	66	122	58	20	2.38 (2.26-2.50)
Women						
Enjoyment (n = 422)	8	13	72	165	164	4.10 (4.01-4.19)
Socializing (n = 418)	23	40	102	142	111	3.67 (3.56-3.77)
Health (n = 429)	5	5	22	128	269	4.52 (4.45-4.59)
Others' expectations (n = 418)	225	85	73	26	9	1.83 (1.72-1.93)
Physical fitness (n = 427)	2	2	28	109	286	4.58 (4.52-4.65)
Psychological well-being (n = 427)	5	3	27	140	252	4.48 (4.41-4.55)
Appearance (n = 422)	111	69	121	81	40	2.69 (2.57-2.82)

Abbreviation: CI, confidence intervals.

consent. All study methods were carried out in accordance with the approved guidelines and the Helsinki Declaration.

3 | RESULTS

The basic descriptive characteristics of the study participants are shown in Table 1. Men and women did not differ with regard to their body mass index ($P = .91$). Men were more physically active based on accelerometer-measured time spent on moderate-to-vigorous physical activity than women (48% vs 43%, $P = .005$). Based on the survey questions, a relatively higher amount of men than women reported engaging in moderate-to-vigorous physical activity (20% vs 17%, $P < .001$), which is in line with the accelerometer data. On the other hand, men reported more sedentary behavior (sitting time) than women (12% vs 9%), while women reported more light physical activity than men (74% vs 68%). However, there were no differences in self-reported physical fitness or subjective health status between older men and women ($P = .51$ and $P = .40$, respectively), nor did the existence of physician-diagnosed diseases that hinder physical activity or the ability to walk 2 kilometers differ between sexes ($P = .92$ and $P = .32$, respectively).

3.1 | Motives for physical activity

We analyzed the motives for physical activity both in the pooled groups of men and women and separately for men and women (Table 2). When men and women were analyzed together, the most important motive for physical activity with the highest mean score was physical fitness, followed by health maintenance and psychological well-being (Table 2). The least important motives with the lowest mean scores for physical activity among all individuals were related to conforming to others' expectations and appearance. Despite the fact that older men and women reported the same motives for physical activity to be important sex-specific analyses revealed that there were some differences in motives for physical activity (Table 3). Conforming other people's expectations was significantly more important for men ($P < .001$, Cohen's $d = 0.38$), while appearance ($P = .001$ Cohen's $d = -0.24$) and psychological well-being ($P = .02$, Cohen's $d = -0.17$) were highlighted by women.

3.2 | Motives for physical activity and accelerometer-measured physical activity

Most of the motive dimensions were statistically significantly and positively correlated with each other (Table 4). Further analyses revealed that accelerometer-measured time spent on moderate-to-vigorous physical activity was also statistically significantly and positively correlated with five motivational factors out of seven (Table 4). The strongest association was found between moderate-to-vigorous physical activity and enjoyment ($r = .38$) followed by physical fitness ($r = .29$), health maintenance ($r = .25$), and psychological well-being ($r = .25$). Though the association with the motive dimension of socializing was significant, it was quite weak ($r = .09$, $P < .05$). However, motive dimensions related to conforming to others' expectations and appearance were not found to be associated with accelerometer-measured time spent on moderate-to-vigorous physical activity in older individuals.

Differences in the motive dimensions between the quintiles of accelerometer-measured time spent on moderate-to-vigorous physical activity by sex are presented in Table 5. The table shows that there are statistically significant differences in the motive dimensions of enjoyment, health maintenance, physical fitness, and psychological well-being between the different quintile groups of accelerometer-measured time spent on moderate-to-vigorous physical activity. This was true for both sexes. When we compared those in the lowest and highest quintiles of accelerometer-measured time

TABLE 3 Differences in the motive dimensions of physical activity between older men and women

Motive dimension	Men Mean (95% CI)	Women Mean (95% CI)	Mean difference (95% CI)	*p*-value	Effect size Cohen's *d*
Enjoyment	4.06 (3.95-4.17)	4.10 (4.01-4.19)	−0.04 (−0.18-0.10)	.57	−0.04
Socializing	3.51 (3.39-3.63)	3.67 (3.55-3.78)	−0.16 (−0.32-0.00)	.06	−0.14
Health	4.45 (4.37-4.53)	4.52 (4.44-4.59)	−0.07 (−0.18-0.04)	.22	−0.09
Others' expectations	2.26 (2.13-2.39)	1.83 (1.71-1.94)	0.43 (0.26-0.60)	<.001	0.38
Physical fitness	4.56 (4.49-4.63)	4.58 (4.51-4.65)	−0.02 (−0.11-0.08)	.73	−0.03
Psychological well-being	4.34 (4.25-4.43)	4.48 (4.41-4.55)	−0.14 (−0.25-−0.03)	.02	−0.17
Appearance	2.38 (2.26-2.51)	2.69 (2.56-2.83)	−0.31 (−0.49-−0.13)	.001	−0.24

Note: The number of older twin individuals in the motive dimensions ranged between 401 and 409 in men and between 418 and 429 in women.

Abbreviation: CI, confidence interval.

TABLE 4 Polychoric correlations between motive dimensions and polyserial correlations between motive dimensions and accelerometer-measured time spent on moderate-to-vigorous physical activity among older individuals

	Enjoyment	Socializing	To maintain health	Others' expectations	Physical fitness	Psychological well-being	Appearance	Accelerometer-measured MVPA
Enjoyment	1 (n = 830)							
Socializing	0.57*** (n = 820)	1 (n = 825)						
Health	0.67*** (n = 829)	0.42*** (n = 825)	1 (n = 837)					
Others' expectations	0.06 (n = 815)	0.23*** (n = 812)	0.01 (n = 817)	1 (n = 819)				
Physical fitness	0.63*** (n = 828)	0.35*** (n = 823)	0.86*** (n = 832)	−0.02 (n = 817)	1 (n = 835)			
Psychological well-being	0.60*** (n = 829)	0.43*** (n = 825)	0.71*** (n = 834)	0.04 (n = 818)	0.84*** (n = 832)	1 (n = 836)		
Appearance	0.29*** (n = 825)	0.31*** (n = 823)	0.34*** (n = 828)	0.46*** (n = 818)	0.29*** (n = 827)	0.41*** (n = 829)	1 (n = 830)	
Accelerometer-measured MVPA	0.38*** (n = 773)	0.09* (n = 771)	0.25*** (n = 780)	−0.06 (n = 764)	0.29*** (n = 779)	0.25*** (n = 779)	0.02 (n = 774)	1 (n = 791)

Abbreviation: MVPA, moderate-to-vigorous physical activity.

*P < .05.

***P < .001.

spent on moderate-to-vigorous physical activity (Table 6), we found that most of the motive dimensions were significantly more important for moderately to vigorously physically active older individuals (the highest quintile) than for inactive (the lowest quintile) older individuals (*P*-values ranged from <.001 to .03). However, the social aspect of physical activity ($P = .22$, Cohen's $d = 0.84$) and others' expectations to be physically active ($P = .58$, Cohen's $d = -0.10$) along with appearance ($P = .63$, Cohen's $d = 0.08$) did not differ between moderately to vigorously active and inactive older men. In women, conforming to others' expectations ($P = .03$, Cohen's $d = -0.36$) was more important for moderately to vigorously physically inactive older women and only the motive dimension of appearance ($P = .94$, Cohen's $d = -0.01$) did not differ between moderately to vigorously physically active and inactive older women. The accelerometer-measured time of moderate-to-vigorous physical activities for active older individuals ranged between 61 and 98 min/d and for inactive counterparts between 2 and 30 min/d.

Because our analyses included older individuals with and without physician-diagnosed diseases hindering physical activity, we conducted a sensitivity analysis to examine whether these two groups of older individuals differed in terms of motivational factors (Table S1). The results showed no significant differences in motivational factors between older individuals with and without physician-diagnosed diseases hindering physical activity except the motive dimension related to the enjoyment of physical activity—older individuals who reported that they had physician-diagnosed diseases that hinder their physical activity were motivated significantly more by enjoyment than older individuals with no such diseases ($P = .001$).

3.3 | Genetic and environmental contributions to motives for physical activity

The intra-class correlation coefficients and quantitative genetic modeling for motives for physical activity were provided to better understand the role of genetic and environmental influences in explaining individual differences in motives for physical activity. The intra-class correlation coefficients were systematically higher, though not all were statistically significantly higher, among MZ pairs (from 0.03 to 0.60) than among DZ pairs (from −0.01 to 0.32) with a few exceptions (Table 7) indicating that genetic factors may be important in these motives for physical activity in older individuals. Most DZ twin correlations that were lower than MZ twin correlations were, however, less than half the MZ correlations, which suggests that environmental factors shared by co-twins play a less important role in motives for physical activity. This suggestion was confirmed by the fact that the best-fitting genetic models were found to be models without

TABLE 5 Differences in the motive dimensions between the quintiles of accelerometer-measured time spent on moderate-to-vigorous activity by sex

Dimension	1st quintile of MVPA Mean (95% CI)	2nd quintile of MVPA Mean (95% CI)	3rd quintile of MVPA Mean (95% CI)	4th quintile of MVPA Mean (95% CI)	5th quintile of MVPA Mean (95% CI)	*P*-value
Enjoyment						
Men	3.52 (3.23-3.82)	3.74 (3.49-4.00)	4.10 (3.91-4.29)	4.37 (4.22-4.53)	4.51 (4.32-4.69)	<.001
Women	3.57 (3.34-3.80)	4.05 (3.86-4.22)	4.21 (4.03-4.39)	4.41 (4.26-4.56)	4.39 (4.19-4.59)	<.001
Socializing						
Men	3.34 (3.04-3.64)	3.37 (3.09-3.66)	3.55 (3.25-3.85)	3.67 (3.44-3.91)	3.59 (3.36-3.83)	.33
Women	3.49 (3.22-3.76)	3.59 (3.37-3.81)	3.66 (3.41-3.90)	3.81 (3.57-4.05)	3.90 (3.63-4.17)	.05
Health						
Men	4.15 (3.91-4.39)	4.25 (4.05-4.46)	4.52 (4.38-4.66)	4.64 (4.52-4.76)	4.66 (4.52-4.79)	<.001
Women	4.24 (4.05-4.43)	4.53 (4.39-4.67)	4.56 (4.41-4.71)	4.80 (4.70-4.89)	4.56 (4.38-4.75)	<.001
Others' expectations						
Men	2.38 (2.05-2.72)	2.09 (1.78-2.40)	2.16 (1.89-2.43)	2.35 (2.08-2.63)	2.26 (2.01-2.51)	.27
Women	2.11 (1.87-2.34)	1.83 (1.61-2.05)	1.62 (1.41-1.84)	1.75 (1.50-2.00)	1.72 (1.46-1.99)	.10
Physical fitness						
Men	4.23 (4.01-4.45)	4.52 (4.36-4.68)	4.65 (4.53-4.77)	4.67 (4.56-4.79)	4.73 (4.61-4.85)	<.001
Women	4.24 (4.07-4.41)	4.63 (4.49-4.77)	4.65 (4.52-4.77)	4.80 (4.70-4.90)	4.64 (4.46-4.81)	<.001
Psychological well-being						
Men	3.93 (3.67-4.19)	4.27 (4.05-4.49)	4.38 (4.20-4.57)	4.53 (4.38-4.68)	4.51 (4.35-4.67)	<.001
Women	4.16 (3.98-4.34)	4.48 (4.31-4.64)	4.59 (4.46-4.72)	4.65 (4.52-4.77)	4.57 (4.36-4.79)	<.001
Appearance						
Men	2.49 (2.18-2.81)	2.13 (1.83-2.44)	2.23 (1.94-2.51)	2.40 (2.14-2.66)	2.59 (2.34-2.84)	.21
Women	2.56 (2.29-2.82)	2.80 (2.51-3.08)	2.85 (2.56-3.13)	2.70 (2.39-3.00)	2.54 (2.25-2.83)	.58

Note: The number of twin individuals in the motive dimensions ranged between 60 and 96 in men and between 61 and 92 in women in the different quintiles of moderate-to-vigorous physical activity.

Abbreviation: CI, confidence intervals; MVPA, moderate-to-vigorous physical activity.

TABLE 6 Differences in the motive dimensions between moderately to vigorously physically inactive (the lowest quintile) and active (the highest quintile) older individuals by sex

Motive dimension	Physically inactive (the lowest quintile of MVPA) Mean (SD)	Physically active (the highest quintile of MVPA) Mean (SD)	Mean difference (95% CI)	*P*-value	Effect size Cohen's *d*
Enjoyment					
Men	3.52 (1.15)	4.51 (0.91)	0.98 (0.61-1.35)	<.001	0.97
Women	3.57 (1.09)	4.39 (0.78)	0.82 (0.52-1.12)	<.001	0.84
Socializing					
Men	3.34 (1.15)	3.59 (1.17)	0.25 (−0.15-0.65)	.21	0.22
Women	3.49 (1.26)	3.90 (1.04)	0.41 (0.03-0.79)	.03	0.35
Health					
Men	4.15 (0.95)	4.66 (0.66)	0.51 (0.21-0.80)	.001	0.65
Women	4.24 (0.91)	4.56 (0.74)	0.32 (0.05-0.59)	.02	0.38
Others' expectations					
Men	2.38 (1.30)	2.26 (1.19)	−12.17 (−0.56-0.31)	.58	−0.10
Women	2.11 (1.12)	1.72 (1.03)	−0.39 (−0.75-−0.03)	.03	−0.36
Physical fitness					
Men	4.23 (0.86)	4.73 (0.61)	0.50 (0.23-0.77)	<.001	0.70
Women	4.24 (0.81)	4.64 (0.68)	0.40 (0.15-0.64)	.002	0.52
Psychological well-being					
Men	3.93 (1.01)	4.51 (0.78)	0.58 (0.26-0.89)	.001	0.66
Women	4.16 (0.87)	4.57 (0.85)	0.41 (0.13-0.69)	.005	0.48
Appearance					
Men	2.49 (1.23)	2.59 (1.23)	0.10 (−0.31-0.50)	.63	0.08
Women	2.56 (1.28)	2.54 (1.12)	−0.01 (−0.43-0.40)	.94	−0.01

Note: The number of twin individuals in the motive dimensions ranged between 92 and 96 in men and between 61 and 62 in women in the highest quintile of moderate-to-vigorous physical activity, while the number of twin individuals ranged between 60 and 61 in men and between 88 and 92 in women in the lowest quintile of moderate-to-vigorous physical activity.

Abbreviations: CI, confidence interval; MVPA, moderate-to-vigorous physical activity; SD, standard deviation.

shared environmental components. According to the best fitting genetic models, the genetic influences contributing to the different motive dimensions of physical activity ranged from 5% to 42% (Table 8). These low-to-moderate estimates of genetic influences indicate a greater role of unique environmental influences, which ranged from 58% to 95% (Table 8).

4 | DISCUSSION

This study was designed to investigate motives for physical activity in older individuals in their 70s. The study identified that in both older men and women, keeping physically and psychologically healthy and fit, along with enjoyment, were the most important drivers of motivation to be physically active. However, the detailed analyses showed that psychological well-being was highlighted by older women more than older men, while being physically active because other people expected one to do so was more important for older men than older women. As hypothesized, appearance as a motivational factor for physical activity was more essential for older women than for older men.

We found that those motivational factors that were less frequently reported by older individuals (ie, conforming to others' expectations and appearance) were less associated with the current level of accelerometer-measured time spent on moderate-to-vigorous physical activity. Thus, these motives did not differ between moderately to vigorously physically inactive and active older individuals, except for conforming to others' expectations in older women. However, older individuals who were moderately to vigorously physically active were motivated significantly more by the enjoyment of physical activity, health, physical fitness, and psychological well-being than moderately to vigorously physically inactive

TABLE 7 Intra-class correlation coefficients (ICC) of motive dimensions by zygosity and the difference between MZ and DZ correlations

Motive dimension	Sex	ICC MZ twins r^2 (95% CI)	Number of twin pairs	ICC DZ twins, same-sex r^2 (95% CI)	Number of twin pairs	*P*-value
Enjoyment	Men	0.60 (0.42-0.79)	60	0.04 (−0.19-0.28)	79	<.001
	Women	0.34 (0.14-0.53)	67	−0.01 (−0.25-0.22)	80	.004
Socializing	Men	0.51 (0.34-0.68)	73	0.05 (−0.18-0.28)	120	<.001
	Women	0.21 (−0.05-0.47)	72	−0.05 (−0.25-0.16)	119	.13
Health	Men	0.42 (0.19-0.65)	61	0.15 (−0.05-0.36)	79	.02
	Women	0.22 (−0.07-0.51)	68	−0.01 (−0.22-0.20)	84	.07
Others' expectations	Men	0.17 (−0.13-0.46)	57	0.32 (0.12-0.53)	77	.20
	Women	0.48 (0.21-0.76)	66	0.28 (0.06-0.51)	80	.05
Physical fitness	Men	0.38 (0.03-0.72)	61	0.10 (−0.11-0.31)	79	.01
	Women	0.14 (−0.12-0.41)	68	0.09 (−0.12-0.31)	82	.67
Psychological well-being	Men	0.10 (−0.15-0.34)	61	0.03 (−0.16-0.23)	79	.54
	Women	0.03 (−0.20-0.25)	67	−0.04 (−0.26-0.19)	83	.93
Appearance	Men	0.22 (−0.04-0.49)	61	0.08 (−0.15-0.31)	79	.24
	Women	0.40 (0.16-0.65)	67	0.12 (−0.10-0.35)	82	.01

Abbreviations: CI, confidence intervals; DZ, dizygotic; MZ, monozygotic.

TABLE 8 Genetic and environmental contributions to the motive dimension of physical activity in older individuals

	Relative variance components	
Motive dimension	A (95% CI)	E (95% CI)
Enjoyment	0.38 (0.23-0.51)	0.62 (0.49-0.77)
Socializing	0.29 (0.12-0.44)	0.71 (0.56-0.88)
Health	0.24 (0.10-0.38)	0.76 (0.62-0.90)
Others' expectations	0.42 (0.29-0.53)	0.58 (0.47-0.71)
Physical fitness	0.19 (0.05-0.32)	0.81 (0.68-0.95)
Psychological well-being	0.05 (−0.10-0.19)	0.95 (0.81-1.10)
Appearance	0.32 (0.16-0.45)	0.68 (0.55-0.84)

Abbreviations: A, genetic influences; E, unique environmental influences.

older individuals. Social aspects related to physical activity were also more important for moderately to vigorously physically active older women than for inactive older women, but in older men, there was no difference in this motivational factor.

Comparisons of our findings with those of previous systematic reviews evaluating older individuals' motives for physical activity[9,10] reveal that physical and psychological health and well-being, as well as enjoyment, seem to be major and universal motivational factors to be physically active in older individuals. Previous studies have also indicated the social aspects of physical activity as important motivational factors, but we could not confirm this result in the present study. Interestingly, health professionals' advice was highlighted as a motive for physical activity in previous review findings,[9] while in our study, motives related to conforming to other people's expectations (including such people as various health professionals mentioned in the previous review, as well as spouses and family members) were the least important motivational factors for older twin individuals, particularly men. This comparison of the results may be weak because it is difficult to know what a person's true reasons are for following professionals' advice. But if there is a real inconsistency between these results, it might be related to the age difference—the age range of the participants was wide in the review,[9] while in our study the age range was narrow, including only individuals in their early 70s.

In accordance with the previous results of van Uffelen et al (2017),[6] our study demonstrated that the major motives for physical activity were the same for both men and women. However, clear differences by sex were seen in motives that were less frequently reported by the participants in both studies. Not only women in their 70s in the present study but also women in their 60s [6] and in even younger age-groups [11] report appearance to be a more important factor to be physically active than men. This seems to indicate that women of all ages place value on their looks and appearance. Our present results further indicate that older women find appearance to be an important motivational factor, independent of their current physical activity level.

We were also able to confirm the previous evidence of an association between motives for physical activity and the current level of physical activity.[1,3,14] In our study, the moderately to vigorously physically active older individuals, particularly women, reported higher frequencies for most of the motivational factors compared to their inactive counterparts, which is consistent with previous studies among older individuals that have indicated differences in many of these same motivational factors, such as physical and psychological health,[1,3,14] fitness,[1,3,14] enjoyment,[1,14] and the social aspects of physical activity.[1,14] In addition to these differences, we also found a difference in the opposite direction: Conforming to others' expectations was a more important motivational factor for inactive older women than active older women (the result was similar in men but the difference was not statistically significant). However, this finding was inconsistent with our previous results, in which we found no significant difference in conforming to other people's expectations between 60-year-old inactive and active twin individuals who had been discordant for physical activity over 30 years.[3] We used the same REMM motivational measure in both studies, but the differing results may partly be explained by (a) a very small sample size in the study of discordant twin pairs, potentially causing insufficient statistical power in that study or (b) the fact that the REMM measure was modified in the present study. Moreover, self-reported physical activity has been used in previous studies, while accelerometer-measured physical activity was used in the present study, which may be a possible cause of inconsistency as well. However, our current findings broadly support the work of other studies in this area suggesting that intrinsic motives (such as enjoyment of physical activity) are linked to regular physical activity behavior (physically active individuals),[34] while extrinsic motives (such as others' expectations) are dominant during the early stages of behavior adoption (physically inactive individuals).[21,35,36]

As far as we know, no previous studies in older individuals have paid attention to the role of the genetic and environmental factors potentially influencing motives for physical activity. However, many human behavioral traits are due to both genetic and environmental factors, and studying the contribution of them provides a valuable insight into the background of traits. In our previous study, we were able to show that genetic and unique environmental effects explain the variation in motives for physical activity in Finnish twins in their mid-30s.[16] In the present study, we were able to replicate these results in Finnish twins in their 70s. Together, these results indicate a role of genetic factors behind individual differences in motives for physical activity. Furthermore, in accordance with younger adults, we again found that the unique environment (ie, all environmental factors not shared by co-twins) also plays a major role in explaining motives for physical activity. More precisely, relative genetic and unique environmental variances in the motive dimensions of the present study are in line with those obtained by our previous study, with the exceptions of the motive dimensions of others' expectations and psychological well-being. The motive dimension of others' expectations was less genetically driven in adults in their mid-30s (13%-15%) [16] than in older adults in the present study (42%), while the motive dimension of psychological well-being was more genetically driven (24%-29%) in adults in their mid-30s [16] than in older adults in the present study (5%).

Some limitations with regard to this study need to be considered. Motives for physical activity were self-reported in this study, which can be an issue and the possibility of errors cannot be avoided. However, self-reports are the only feasible way to measure human motives. Furthermore, the motivation measure we used was abbreviated and modified, which may have consequences for the validity and reliability of the findings. Possibly, these changes may have further affected the conclusions made of the results. Because we used a genetically informative twin study design, a number of assumptions need to be made to obtain a refined estimate of the genetic influences.[37] One of the most important assumptions is that twins do not differ from the general population in terms of motives for engaging in physical activity. It is also assumed that people mate randomly, because non-random mating would increase the genetic variance in a population. If these assumptions are not fulfilled, it would have effects on heritability estimates.

Accelerometer-based physical activity assessment is a strength of our study—it is likely that device-based physical activity assessments are more accurate than self-reports.[38] A further strength of the present study is its good statistical power. The large sample size of older individuals with accelerometer-measured physical activity data is still quite unique and ensures that the statistical power is enough to capture the differences in motives for physical activity between different groups of older individuals should they exist. The dataset we used in this study was drawn from a population-based study cohort with relatively equal sex representation and high response rates, which contributes to less selection biases and the good generalizability of the study findings. The minimal selection bias of the MOBILETWIN study is further supported by the fact that some of the individuals who participated in the accelerometer study did not have complete physical activity data from the previous questionnaire surveys, but they did not differ significantly from those individuals with complete baseline data.[19] There are also speculations whether twins are representative of the general population but previous studies have shown that twins do not differ from the general population of non-twins on many traits, morbidity and behavior.[39,40]

In order to represent the reality of older individuals as truthfully as possible, we decided to also include older individuals with physician-diagnosed diseases hindering physical activity in the analyses. This can be a potential concern for the representativeness of this study. To make sure that our analyses with all participants who had data available were representative, we conducted a sensitivity analysis with those older individuals who had and did not have physician-diagnosed diseases. No evidence was found that the individuals with physician-diagnosed diseases differed significantly in terms of motives for physical activity, except enjoyment, from those who were not diagnosed with such diseases.

4.1 | Perspective

The present study set out to broadly investigate motives for physical activity among a population over 70 years of age, which is a growing group of inactive individuals. Currently, emerging evidence has suggested that although motives for physical activity vary by many factors, there seems to exist motives for physical activity in older individuals that are very general to all people, such as physical and psychological health. Our findings clearly indicate that the leading motivational factors in older individuals are these general ones and are the same for both sexes, while sex differences exist in less important motivational factors. Individual differences for some motives are also found to be based on the current level of physical activity and are partly explained by genetic factors. Based on our results, it should be remembered that one approach does not suit all when planning physical activity interventions for older inactive people. For example, this study suggests that older men will become more easily motivated if they find that there is someone who is expecting them to be physically active, while older women will become more physically active if they find physical activity as a way to achieve a better appearance and psychological well-being.

ACKNOWLEDGEMENTS

The MOBILETWIN study was supported by the Finnish Ministry of Education and Culture (grant OKM/56/626/2013 to UMK). The research work has further been supported by the Academy of Finland (grant 266592 to SA and KS and grants 100499, 205585, 141054, 265240, 263278, 264146 and 312073 to JK), the Finnish Ministry of Education and Culture (to SA and KS), the Juho Vainio Foundation (to SA and KS), and the Finnish Cultural Foundation (to SA). The results of our study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation. None of the authors have any conflict of interest regarding the content of this manuscript.

ORCID

Sari Aaltonen https://orcid.org/0000-0002-2873-4263
Katja Waller https://orcid.org/0000-0002-0121-249X
Henri Vähä-Ypyä https://orcid.org/0000-0001-7537-2501
Juha Rinne https://orcid.org/0000-0001-6369-0764
Harri Sievänen https://orcid.org/0000-0003-3172-248X
Karri Silventoinen https://orcid.org/0000-0003-1759-3079
Jaakko Kaprio https://orcid.org/0000-0002-3716-2455
Urho M. Kujala https://orcid.org/0000-0002-9262-1992

REFERENCES

1. Dacey M, Baltzell A, Zaichkowsky L. Older adult's intrinsic and extrinsic motivation toward physical activity. *Am J Health Behav*. 2008;32(6):570-582.
2. Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJ, Martin BW. Lancet Physical Activity Series Working Group. Correlates of physical activity: Why are some people physically active and others not? *Lancet*. 2012;380(9838):258-271.
3. Aaltonen S, Leskinen T, Morris T, et al. Motives for and barriers to physical activity in twin pairs discordant for leisure time physical activity for 30 years. *Int J Sports Med*. 2012;33(2):157-163.
4. Sun F, Norman IJ, While AE. Physical activity in older people: A systematic review. *BMC Public Health*. 2013; 13(1):13-449.
5. World Health Organization. Ageing and health. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. Accessed June 19, 2019.
6. van Uffelen JGZ, Khan A, Burton NW. Gender differences in physical activity motivators and context preferences: a population-based study in people in their sixties. *BMC Public Health*. 2017;17(1):624.
7. Trujillo KM, Brougham RR, Walsh DA. Age differences in reasons for exercising. *Curr Psych*. 2004;22(4):348-367.
8. Gallagher P, Yancy WS Jr, Swartout K, Denissen JJA, Kuhnel A, Voils CI. Age and sex differences in prospective effects of health goals and motivations on daily leisure-time physical activity. *Prev Med*. 2012;55(4):322-324.
9. Baert V, Gorus E, Mets T, Geerts C, Bautmans I. Motivators and barriers for physical activity in the oldest old: a systematic review. *Ageing Res Rev*. 2011;10(4):464-474.
10. Cavill NA, Foster CEM. Enablers and barriers to older people's participation in strength and balance activities: a review of reviews. *JFSF*. 2018;3(2):105-113.
11. Molanorouzi K, Khoo S, Morris T. Motives for adult participation in physical activity: type of activity, age, and gender. *BMC Public Health*. 2015;15:66.
12. Hirvensalo M, Lampinen P, Rantanen T. Physical exercise in old age: An eight-year follow-up study on involvement, motives, and obstacles among persons age 65–84. *J Aging Phys Act*. 1998;6:157-168.
13. De Pero R, Amici S, Benvenuti C, Minganti C, Capranica L, Pesce C. Motivation for sport participation in older Italian athletes: the role of age, gender and competition level. *Sport Sci Health*. 2009;5:61-69.
14. Costello E, Kafchinski M, Vrazel J, Sullivan P. Motivators, barriers, and beliefs regarding physical activity in an older adult population. *J Geriatr Phys Ther*. 2011;34(3):138-147.
15. Posthuma D, Beem AL, de Geus EJ, et al. Theory and practice in quantitative genetics. *Twin Res*. 2003;6(5):361-376.

16. Aaltonen S, Kaprio J, Vuoksimaa E, Huppertz C, Kujala UM, Silventoinen K. Genetic architecture of motives for leisure-time physical activity: A twin study. *Scand J Med Sci Sports*. 2017;27(11):1431-1441.
17. Kaprio J, Sarna S, Koskenvuo M, Rantasalo I. The Finnish twin registry: Formation and compilation, questionnaire study, zygosity determination procedures, and research program. *Prog Clin Biol Res*. 1978;24:179-184.
18. Jelenkovic A, Ortega-Alonso A, Rose RJ, Kaprio J, Rebato E, Silventoinen K. Genetic and environmental influences on growth from late childhood to adulthood: A longitudinal study of two Finnish twin cohorts. *Am J Hum Biol*. 2011;23(6):764-773.
19. Waller K, Vähä-Ypyä H, Törmäkangas T, et al. Long-term leisure-time physical activity and other health habits as predictors of objectively monitored late-life physical activity - a 40-year twin study. *Sci Rep*. 2018;8(1):9400
20. Rogers H, Morris T. An overview of the development and validation of the recreational exercise motivation measure (REMM). XIth European Congress of Sport Psychology Proceedings Book, Copenhagen, Denmark. 2003:144.
21. Deci E, Ryan RM. *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press; 1985.
22. Schrack JA, Leroux A, Fleg JL, et al. Using heart rate and accelerometry to define quantity and intensity of physical activity in older adults. *J Gerontol A Biol Sci Med Sci*. 2018;73(5):668-675.
23. Husu P, Suni J, Vähä-Ypyä H, et al. Objectively measured sedentary behavior and physical activity in a sample of Finnish adults: a cross-sectional study. *BMC Public Health*. 2016;16:920.
24. Waller K, Vähä-Ypyä H, Lindgren N, Kaprio J, Sievänen H, Kujala UM. Self- reported fitness and objectively measured physical activity profile among older adults: a twin study. *J Gerontol A Biol Sci Med Sci*. 2019;74(12):1965-1972.
25. Pajunen K. *Vapaa-ajan liikunnan motivaatiomittarin psykometriset ominaisuudet. Master's Thesis in Finnish*. Jyväskylä, Finland: University of Jyväskylä; 2004:42-47.
26. Vähä-Ypyä H, Vasankari T, Husu P, Suni J, Sievänen H. A universal, accurate intensity-based classification of different physical activities using raw data of accelerometer. *Clin Physiol Funct Imaging*. 2015;35(1):64-70.
27. Vähä-Ypyä H, Vasankari T, Husu P, et al. Validation of cut-points for evaluating the intensity of physical activity with accelerometry-based mean amplitude deviation (MAD). *PLoS ONE*. 2015;10(8):e0134813.
28. Vähä-Ypyä H, Husu P, Suni J, Vasankari T, Sievänen H. Reliable recognition of lying, sitting, and standing with a hip-worn accelerometer. *Scand J Med Sci Sports*. 2018;28(3):1092-1102.
29. Sievänen H, Kujala UM. Accelerometry-simple, but challenging. *Scand J Med Sci Sports*. 2017;27(6):574-578.
30. Kujala UM, Hautasaari P, Vähä-Ypyä H, et al. Chronic diseases and objectively monitored physical activity profile among aged individuals—a cross-sectional twin cohort study. *Ann Med*. 2019;51(1):78-87.
31. Boomsma D, Busjahn A, Peltonen L. Classical twin studies and beyond. *Nat Rev Genet*. 2002;3(11):872-882.
32. Rijsdijk FV, Sham PC. Analytic approaches to twin data using structural equation models. *Brief Bioinform*. 2002;3(2):119-133.
33. Little RJA, Rubin DB. *Statistical analysis with missing data*, 2nd edn. Hoboken USA: John Wiley; 2002.
34. Teixeira PJ, Carraca EV, Markland D, Silva MN, Ryan RM. Exercise, physical activity, and self-determination theory: a systematic review. *Int J Behav Nutr Phys Act*. 2012;9:78.
35. Ingledew DK, Markland D, Medley AR. Exercise motives and stages of change. *J Health Psych*. 1998;3(4):447-489.
36. Ryan RM, Frederick CM, Lepes D, Rubio N, Sheldo KM. Intrinsic motivation and exercise adherence. *Int J Sport Psychol*. 1997;28:335-354.
37. Neale MC, Cardon LR. *Methodology for genetic studies of twins and families*. Dordrecht: Kluwer Academic Publishers BV; 1992.
38. Helmerhorst HJF, Brage S, Warren J, Besson H, Ekelund U. Ekelund U. A systematic review of reliability and objective criterion-related validity of physical activity questionnaires. *Int J Behav Nutr Phys Act*. 2012;9-103.
39. Evans DM, Martin NG. The validity of twin studies. *GeneScreen*. 2008;1(2):77-79.
40. Barnes JC, Boutwell BB. A demonstration of the generalizability of twin-based research on antisocial behavior. *Behav Genet*. 2013;43(2):120-131.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Aaltonen S, Waller K, Vähä-Ypyä H, et al. Motives for physical activity in older men and women: A twin study using accelerometer-measured physical activity. *Scand J Med Sci Sports*. 2020;30:1409–1422. https://doi.org/10.1111/sms.13673