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Associations of physical activity with positive mental health: A population-based study

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ABSTRACT

Introduction: The relationship between physical activity (PA) and positive mental health (PMH) has been studied mainly by either concentrating on total PA or focusing on leisure time PA. This study investigated whether total PA and PA domains of leisure time, commuting and occupational PA and screen time sitting at home were associated with PMH.

Methods: The study used a national population study, the FinHealth 2017 Study that included the Warwick-Edinburgh Mental Well-being Scale (WEMWBS) as a measurement for PMH. Of all (n = 10305, of whom 10247 were eligible) invited, 58.1% (5952) participated in health examination and were given a questionnaire including the WEMWBS. A total of 5337 (52.1% of the eligible sample, 89.7% of the health examination participants) returned the questionnaire. The WEMWBS scale was adequately completed by 5090 participants (55.6% women, mean age 55.5 years). Low, moderate and high level of PMH categories were formed. Leisure time, occupational and commuting PA domains were assessed separately and together as a total PA index. Also, screen time sitting at home was measured. Binary logistic regression models were utilized to estimate the odds ratios for having low PMH compared with moderate PMH and separately for having high PMH compared with moderate PMH. The models were estimated both with and without adjustment for potential confounders.

Results: Physical inactivity (total PA) was associated with lower levels of PMH. Some of the PA domains were strongly associated with low PMH; leisure time physical inactivity and long screen time sitting at home were strongly related to higher odds of low PMH. Commuting PA was associated with high PMH.

Conclusions: The study highlights the importance of PA with relation to PMH among adults. Especially, physical inactivity was strongly associated with low PMH. As low levels of PMH can potentially present a risk for mental ill-health, this study suggests it is important to increase PA among the least active population.

1. Introduction

The World Health Organization (WHO) has defined positive mental health as "a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community" (WHO, 2018, p. 1). Positive mental health (PMH) is thus based on the assumption that mental health is something positive and a resource for well-being, and more than just the absence of mental illness (WHO, 2018). The term is often used interchangeably with the term mental well-being. PMH is understood to comprise two main elements: feeling good (hedonic perspective) and functioning well (eudaimonic perspective). The hedonic perspective focuses on the subjective experience of happiness and life satisfaction, and the eudaimonic perspective on psychological functioning and self-realisation (Ryan & Deci, 2001; Stewart-Brown, 2015). PMH includes aspects such as self-esteem, optimism, a sense of mastery and coherence, satisfying personal relationships and resilience, that is, the ability to cope with

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adversities and face stressors (Huppert, 2009; Lehtinen, 2008; Vaillant, 2012).

PMH is currently receiving increased attention in research, policy making and clinical practice (EU Joint Action, 2016; Forsman et al., 2015). It has been recognized as a key resource for the health and well-being of individuals, families and societies (Huppert, 2009; Jenkins et al., 2008; Wahlbeck, 2011, 2015). Research has shown PMH to be associated with a reduced risk of mortality, better physical health, better academic achievement and social functioning, and with reduced risk for mental illness (Keyes, 2005; Keyes & Simoes, 2012; Suldo & Shaffer, 2008). There is also growing evidence on the economic benefits of promoting PMH. Actions targeted especially at children and adolescents and some work-place interventions have shown to be cost-effective (Zechmeister, Kilian, McDaid, & the MHEEN group, 2008; Knapp, McDaid, & Parsonage, 2011; McDaid, Park, & Wahlbeck, 2019). Improved PMH at work-place, for example, can help employees to stay at work (less sickness and absenteeism) and work to their full productive potential (less presenteeism, i.e. lost productivity while at work). Interventions promoting PMH can also generate significant savings in public health expenditure such as reductions in health and social care costs (Knapp, McDaid, & Parsonage, 2011; Zechmeister et al., 2008).

The association between physical activity (PA) and mental health is well-documented providing strong evidence on mental health benefits of PA (Biddle, 2016; Chekroud et al., 2018; White et al., 2017). However, the focus of previous research has been on mental health problems (Bennie, Teychenne, De Cocker, & Biddle, 2019; Chekroud et al., 2018; Suetani et al., 2017) rather than on the perspective of PMH. There is, nonetheless, growing evidence of the potential benefits of PA in increasing PMH, especially related to leisure time PA (Cerin, Leslie, Sugiyama, & Owen, 2009; Mason, Curl, & Kearns, 2016; Richards et al., 2015; Zhang & Chen, 2019). A report on the 2012/13 North West Mental Wellbeing Survey (Jones et al., 2013) showed that respondents who met the PA target (at least 30 min of moderate-intensity activity on 5–7 days per week) had significantly higher PMH as compared to those who did not meet the target. A study on a community –wide gamification-based PA intervention (Harris, 2018) found that an increase in PA following the intervention was positively correlated with PMH. The study also revealed that increases in PMH were significantly greater for the least active prior to the intervention. Further, clear associations were found between various domains of PA and PMH measure in a study conducted in deprived neighbourhoods in Glasgow (Mason et al., 2016). The researchers found that people engaging in PA for pleasure, through active leisure and family activities and in active travel, generally had better PMH. Commuting PA has shown mixed associations with PMH (Humphreys, Goodman, & Ogilvie, 2013; Mytton, Panter, & Ogilvie, 2016). However, several studies have established a positive relationship between commuting PA and PMH (Martin, Goryakin, & Suhrcke, 2014; Mason et al., 2016; Mytton et al., 2016; White et al., 2017). Majority of the studies (e.g. Harris, 2018; Jones et al., 2013; Mason et al., 2016) investigating the relationship between PA and PMH have been cross-sectional and thus cannot reliably distinguish causality from association.

While increasing number of studies have established associations of leisure time PA and, to some extent, commuting PA with PMH, less is known about the relationships between PA domains such as occupational PA and sedentary behaviour (e.g. screen time sitting) and PMH. Occupational PA has been found to be unrelated or negatively associated with mental well-being (Cerin et al., 2009). Conversely, White and partners (2017) found occupational PA positively associated with mental ill-health. Knowledge about the relationship of sedentary behaviour with mental well-being seems to be non-existent. Some mixing results have been shown regarding sedentary behaviour and mental ill-health (Hamer, Stamatakis, & Mishra, 2010; Teychenne et al., 2014, 2017, 2020).

The relationship between PA and PMH, accordingly, seems to vary between different PA domains (Cerin et al., 2009; White et al., 2017). We had the novel possibility to examine various PA domains in a large national population study, and to look at whether the possible associations with PMH were different depending on the specific PA domain. Furthermore, we explored the potential associations in relation to different levels of PMH. Earlier studies have suggested that associations (e.g. between socioeconomic factors and PMH) with low level of PMH follow a different pattern than associations with high level of PMH (Ng Fat, Mindell, Boniface, & Stewart-Brown, 2016; Stewart-Brown, Samaraweera, Taggart, Kandala, & Stranges, 2015; Stranges, Samaraweera, Taggart, Kandala, & Stewart-Brown, 2014). Differences between predictors of the low end of the mental well-being scale with the high end of the mental well-being scale have also been found with health behaviours such as diet, smoking and alcohol consumption (Stewart-Brown et al., 2015). Thus, the aim of the current study was to investigate whether total PA and PA domains such as leisure time PA, commuting PA, occupational PA and screen time sitting at home were associated with PMH using a large national population study, the FinHealth 2017 Study (Borodulin & Sääksjärvi, 2019). We examined the relationship between PA and levels of low, moderate and high PMH. This is the first study, to our knowledge, to investigate associations between different domains of PA with different levels of PMH in a large population study.

2. Methods

2.1. Study population

The FinHealth 2017 Study is a nationally representative population-based health examination study aiming to collect up-to-date information on the health and well-being of adults residing in Finland, and on the factors influencing their health and well-being (Borodulin & Sääksjärvi, 2019). In 2017, 10 305 persons (of whom 10 247 were eligible) over 18 years of age living in Finland were invited by two-stage clustered random sampling to participate in a health examination. Participation rate in the health examination was 58.1% (5952). The participants underwent clinical measurements and filled in questionnaires. Those who participated in the health examination received a questionnaire that measured PMH with the Warwick-Edinburgh Mental Well-being Scale (WEMWBS) (Tennant et al., 2007). A total of 5337 participants (52.1% of the eligible sample, 89.7% of the health examination participants) returned the questionnaire. The scale was adequately completed by 5090 participants.

2.2. Positive mental health measure

The WEMWBS was used to measure the level of PMH (i.e. mental well-being) of the survey respondents. WEMWBS is a validated, popular measure that covers both subjective well-being (hedonic perspective) and psychological functioning (eudaimonic perspective) addressing aspects of PMH (Tennant et al., 2007). The English version of the WEMWBS has shown good validity and high levels of internal consistency (Cronbach's alpha 0.89/0.91) and reliability (test-retest reliability 0.83). The scale is suitable for use in measuring mental well-being at a population level due to its strong psychometric performance and lack of ceiling effects. (Stranges et al., 2014; Taggart, Stewart-Brown, & Parkinson, 2016; Tennant et al., 2007). The scale is consisted of 14 positively worded items, each item answered on a five-point Likert scale. The item scores are summed to produce a total score ranging between 14 and 70, with higher scores representing higher levels of PMH (Taggart et al., 2016). Finnish, Swedish and English versions of the scale were used in the FinHealth 2017 Study.

Three PMH categories were formed by classifying the WEMWBS scores: low level of PMH if the score was less than one standard deviation (SD) below the mean (score $<$ 44), high level of PMH if the score was more than one SD above the mean (score $>$ 61), and moderate PMH for the rest (Taggart et al., 2016).

2.3. Different domains of PA and total PA index

Three different domains of PA were assessed. These included leisure time PA, occupational PA and commuting PA (Borodulin et al., 2016). In addition, we measured screen time sitting at home (Borodulin & Sääksjärvi, 2019). Leisure time PA was assessed as: "How much do you exercise and stress yourself physically in your leisure time?" The answer options captured both the amount of time and the level of intensity of the PA and were dichotomized into inactive and active. The response of not moving much and not straining physically was categorized as inactive; other three answer categories as active. Occupational PA was assessed as: "How demanding is your work physically?" From the four available response options, four categories of inactive, low, medium and high were established. Commuting PA was measured with a question: "On your way to work or school, how many minutes do you travel on foot, by bicycle or similar? Add up the journeys to and from work/school." The response options ranged from not being at work to more than 60 min per day and were further dichotomized into less than 30 min daily and 30 min or more daily. Screen time sitting at home was measured as: "How many hours on average do you sit in a weekday at home in front of screen?" Responses were given in hours and minutes and were dichotomized into 3 h at most and more than 3 h. The PA questions used in this study have shown good criterion validity against morbidity and mortality (Grimby et al., 2015; Hu et al., 2007) and the leisure time PA question a moderate correlation against accelerometer counts among the working age population (Fagt et al., 2011).

The total PA index was created using the leisure time, commuting and occupational PA questions (Borodulin et al., 2016). Four categories were created: inactivity (inactivity in all PA domains), low (inactivity in leisure time PA; low activity in at least one of commuting PA or occupational PA), medium (moderate in leisure time or occupational PA or 15–29 min in commuting PA and no high activity in any of the domains) and high (high activity in at least one of leisure time, occupational or commuting PA). Full description of the PA questions and the total PA index used in the study is presented in Supplementary File 1.

2.4. Sociodemographic and personal characteristics

Background variables used in the analyses included age, sex, marital status (three categories: married/cohabiting, divorced/widow and single), educational level (low = primary school, middle = vocational school or high school, high = college or university level), household income per consumption unit (total household income divided by the square root of household size) (OECD, 2019), employment status (four categories: in employment or studying, unemployed, retired and other) and self-rated health (four categories: good, rather good, moderate and poor/rather poor [the poorest class was combined with rather poor due to very small frequencies]). The selection of covariates and confounders was based on previous studies from similar data sets, which focused on demographic and socioeconomic correlates of health and well-being (Borodulin & Sääksjärvi, 2019; Stranges et al., 2014; Lundqvist & Mäki-Opas, 2016).

2.5. Statistical methods

Descriptive analyses using χ^2 tests were carried out to test for the associations of PA and sociodemographic variables with PMH levels.

We built models where the outcome variable was categorized PMH. Binary logistic regression models were utilized to estimate the odds ratios for having low PMH compared with moderate PMH and separately for high PMH compared with moderate PMH. The decision to model WEMWBS as a categorical variable rather than continuous was based on the different associations at the low and high end of the spectrum found in previous studies (Ng et al., 2016; Stewart-Brown et al., 2015; Stranges et al., 2014). Models with different numbers of adjusting variables, which were thought to be possible confounders, were fitted separately. Age and household income per consumption unit were treated as continuous variables and total PA index, leisure time PA, screen time sitting at home, occupational PA, commuting PA, sex, marital status, educational level, employment status and self-rated health as categorical variables in logistic regressions. Model 1 was adjusted for age and sex, Model 2 additionally for marital status, educational level, household income per consumption unit, employment status and self-perceived health. Model 3 was adjusted for all the variables. However, Model 3 did not include the total PA index to avoid the problem of multicollinearity, as it included all the other PA variables from which the total PA was derived.

The stratified sampling design was taken into account, and non-participation was adjusted by weighting utilizing the R package survey (Lumley, 2004). The weights were formed using sociodemographic variables and information about hospitalizations obtained from national administrative registers (Borodulin & Sääksjärvi, 2019). For each model, individuals with missing values in variables under consideration were removed. All the analyses were carried out using the R statistical software version 3.5.1 (R Core Team, 2018).

3. Results

Table 1 shows the characteristics of the study participants for different PA and sociodemographic variables by PMH categories. According to these unadjusted numbers, it seemed that all the variables were associated with PMH except commuting PA and sex. Higher levels of PA were usually related to higher PMH and inactivity to lower PMH. Low level of PMH was associated with young age, being single, low education, low household income, unemployment and poor self-perceived health. Old age, being divorced or widowed, high education, high household income, retirement and good self-perceived health were associated with high level of PMH.

The adjusted associations of PA with low and high PMH are presented in Table 2. The upper part of the table shows the odds for having low PMH and the lower part shows the odds for having high PMH. Separate models were fitted to adjust for different sets of sociodemographic and PA variables. Based on the total PA index, having medium or lower level (inactive) of activity compared to having high level of activity increased the odds of having low level of PMH. Inactive persons were 1.47 times more likely to have low PMH than highly active persons. Leisure time physical inactivity (OR = 1.46) and high screen time sitting at home (OR = 1.51) were strongly related to higher odds of low PMH, whereas occupational and commuting PA were not found to associate with low PMH at all.

PA variables were not so strongly related to high level of PMH as to low level of PMH (Table 2). Only commuting PA associated with high PMH. Those who reported physically active commuting 30 min or more daily had 2.05 times higher odds of having high PMH than those with less commuting PA. We also tested whether PA variables associated with PMH differently for men and women, but no evidence of interaction effects was found.

4. Discussion

4.1. Main findings and study implications

This cross-sectional study examined the relationship between PA and PMH in the FinHealth 2017 Study, a large nationally representative sample of the Finnish adult population (Koponen, Borodulin, Lundqvist, Sääksjärvi, & Koskinen, 2018). We had the opportunity to investigate the associations of both total PA levels and different domains of PA with PMH using the WEMWBS as a measure of PMH (Tennant et al., 2007). In addition to looking at PA domains such as leisure time PA, commuting PA and occupational PA, we included sedentary behaviour in the form of screen time sitting at home in our analysis. Moreover, we

Table 1
Sample characteristics and distributions of participants' positive mental health by physical activity and sociodemographic variables.

Total n (5090)	Positive mental health, N (%)			*p*-value[a]	Item non-response, N[c]
	Low	Moderate	High		
	721 (14)	3660 (72)	709 (14)		
Total PA index					6
Inactive	140 (25)	361 (64)	63 (11)	< 0.001	
Low	67 (22)	205 (69)	26 (9)		
Medium	313 (14)	1656 (73)	315 (14)		
High	201 (10)	1433 (74)	304 (16)		
Leisure time PA					46
Inactive	293 (24)	807 (66)	123 (10)	< 0.001	
Active	422 (11)	2815 (74)	584 (15)		
Screen time sitting at home a day					120
3 h at most	391 (12)	2483 (74)	490 (15)	< 0.001	
More than 3 h	313 (19)	1086 (68)	207 (13)		
Occupational PA[b]					101
Inactive	149 (12)	916 (75)	152 (12)	< 0.001	
Low	65 (10)	488 (76)	90 (14)		
Medium	116 (18)	461 (71)	73 (11)		
High	18 (8)	170 (80)	24 (11)		
Commuting PA[b]					75
Less than 30 min daily	305 (13)	1790 (75)	285 (12)	0.130	
30 min or more daily	43 (12)	250 (72)	55 (16)		
Age					0
18–29	58 (18)	235 (74)	24 (8)	< 0.001	
30–49	216 (14)	1155 (76)	152 (10)		
50–69	306 (14)	1519 (71)	323 (15)		
70–100	141 (13)	751 (68)	210 (19)		
Sex					0
Men	329 (15)	1617 (72)	314 (14)	0.772	
Women	392 (14)	2043 (72)	395 (14)		
Marital status					19
Married/cohabiting	428 (12)	2670 (74)	516 (14)	< 0.001	
Divorced/widow	150 (18)	553 (66)	139 (17)		
Single	138 (22)	424 (69)	53 (9)		
Educational level					72
Low	256 (16)	1110 (71)	208 (13)	0.017	
Middle	228 (14)	1207 (73)	224 (14)		
High	221 (12)	1297 (73)	267 (15)		
Household income per consumption unit					171
1st quintile	185 (21)	610 (68)	103 (11)	< 0.001	
2nd quintile	164 (17)	686 (72)	106 (11)		
3rd quintile	155 (13)	833 (72)	163 (14)		
4th quintile	95 (10)	696 (76)	126 (14)		
5th quintile	91 (9)	725 (73)	181 (18)		
Employment status					10
In employment or studying	348 (13)	2047 (75)	340 (12)	< 0.001	
Unemployed	84 (30)	174 (62)	23 (8)		
Retired	251 (13)	1290 (69)	329 (18)		
Other	37 (19)	140 (72)	17 (9)		
Self-rated health					14
Good	64 (5)	972 (73)	301 (23)	< 0.001	
Rather good	231 (11)	1528 (75)	270 (13)		
Moderate	275 (20)	971 (71)	114 (8)		
Poor/rather poor	146 (42)	183 (52)	21 (6)		

Note. N = number, PA = physical activity.
[a] *p*-values from χ^2 tests used to determine possible associations between PA/sociodemographic variables and PMH categories.
[b] Restricted to those who are employed or studying.
[c] Of those who have responded to the WEMWBS scale.

Table 2
Odds ratios and 95% confidence intervals separately for low level of positive mental health (PMH) compared with the moderate level of PMH and for high level of PMH compared with the moderate level of PMH.

		Model 1 (age and sex adjusted), n, OR (95% CI)	Model 2 (sociodemo-graphic factors adjusted[a]), n, OR (95% CI)	Model 3 (fully adjusted[b]), n, OR (95% CI)	*p*-value for interaction with sex[d]
Low PMH compared with moderate PMH	**Total PA index**	n = 4376	n = 4172		0.210
	Inactive	3.20 (2.35, 4.37)	1.47 (1.02, 2.11)		
	Low	2.06 (1.47, 2.89)	1.66 (1.15, 2.40)		
	Medium	1.54 (1.22, 1.96)	1.33 (1.05, 1.68)		
	High	ref.	ref.		
	Leisure time PA	n = 4337	n = 4138	n = 4033	0.742
	Inactive	2.39 (1.95, 2.94)	1.57 (1.26, 1.95)	1.46 (1.18, 1.82)	
	Active	ref.	ref.	ref.	
	Screen time sitting at home a day	n = 4273	n = 4115	n = 4033	0.756
	More than 3h	1.98 (1.60, 2.45)	1.66 (1.31, 2.11)	1.51 (1.19, 1.91)	
	3h at most	ref.	ref.	ref.	
	Occupational PA[c]	n = 2383	n = 2327	n = 2292	0.307
	Inactive	1.01 (0.51, 1.99)	1.50 (0.73, 3.10)	1.36 (0.67, 2.77)	
	Low	0.90 (0.43, 1.88)	1.33 (0.61, 2.93)	1.29 (0.60, 2.77)	
	Medium	1.53 (0.77, 3.03)	1.92 (0.94, 3.92)	1.85 (0.91, 3.74)	
	High	ref.	ref.	ref.	
	Commuting PA[c]	n = 2388	n = 2332	n = 2292	0.786
	Less than 30 min daily	0.94 (0.62, 1.42)	0.94 (0.56, 1.58)	1.00 (0.57, 1.76)	
	30 min or more daily	ref.	ref.	ref.	
High PMH compared with moderate PMH	**Total PA index**	n = 4363	n = 4171		0.341
	Inactive	ref.	ref.		
	Low	0.93 (0.51, 1.70)	1.15 (0.63, 2.10)		
	Medium	1.32 (0.90, 1.95)	1.25 (0.83, 1.88)		
	High	1.80 (1.27, 2.55)	1.34 (0.88, 2.05)		
	Leisure time PA	n = 4329	n = 4141	n = 4033	0.614
	Inactive	ref.	ref.	ref.	
	Active	1.48 (1.16, 1.89)	1.11 (0.84, 1.45)	1.04 (0.78, 1.37)	
	Screen time sitting at home a day	n = 4266	n = 4116	n = 4033	0.767
	More than 3h	ref.	ref.	ref.	
	3h at most	1.36 (1.12, 1.65)	1.22 (0.96, 1.56)	1.20 (0.94, 1.53)	
	Occupational PA[c]	n = 2374	n = 2325	n = 2295	0.142
	Inactive	ref.	ref.	ref.	
	Low	1.14 (0.80, 1.60)	1.20 (0.85, 1.69)	1.20 (0.85, 1.71)	
	Medium	1.13 (0.68, 1.87)	1.10 (0.73, 1.66)	1.09 (0.73, 1.61)	
	High	0.73 (0.47, 1.12)	0.88 (0.50, 1.56)	0.91 (0.53, 1.57)	
	Commuting PA[c]	n = 2380	n = 2331	n = 2295	0.148
	Less than 30 min daily	ref.	ref.	ref.	
	30 min or more daily	1.90 (1.12, 3.24)	2.06 (1.24, 3.42)	2.05 (1.25, 3.39)	

Note. OR = odds ratio, CI = confidence interval, PMH = positive mental health, PA = physical activity.
[a] Adjusted for age, sex, marital status, educational level, household income per consumption unit, employment status and self-perceived health.
[b] Fully adjusted models are adjusted for all the sociodemographic variables and leisure time PA, screen time sitting at home, occupational PA and commuting PA.
[c] Restricted to those who are employed or studying.
[d] Interactions for total PA index tested in Model 2 and for other PA variables in Model 3.

aimed to explore these associations in relation to different levels of PMH as earlier studies have suggested that the associations may follow a different pattern (Stranges et al., 2014; Stewart-Brown et al., 2015; Ng Fat et al., 2016). Our findings give further support to the evidence that the relationship between PA, total and domain-specific, and PMH differ at the low end of the mental well-being scale from the high end of the mental well-being scale. We found that when looking at total PA, physical inactivity was associated with lower levels of PMH. This result, thus, seems to support the earlier notions of the potential benefits of PA in increasing PMH (e.g. Cerin et al., 2009; Harris, 2018; Mason et al., 2016; Zhang & Chen, 2019).

We also found that some of the studied PA domains were strongly associated with low level of PMH. Our data showed that leisure time physical inactivity and long screen time sitting at home were strongly related to higher odds of low PMH. Sedentary behaviour such as long screen time sitting at home in leisure time was thus connected to having low PMH. This is a novel result as the relationship between sedentary behaviour and PMH has been an unexplored research area. These findings could suggest that an increase in leisure time PA and a reduction of screen time sitting at home might have a positive influence on the level of PMH. Leisure time PA is most likely based on one's own preferences and enjoyment (Teychenne et al., 2020; White et al., 2018) which can therefore be seen more easily affecting mental well-being. Furthermore, leisure time PA can provide possibilities for

improvements in self-esteem and mastery of skills or goals (Paluska & Schwenk, 2000; Teychenne et al., 2020), both components of PMH. Regarding sedentary behavior and its association with PMH, more research is needed before we can make any interpretations or implications of the relationship between the two.

Interestingly, we did not find association between occupational PA and PMH thus adding to the scarce and somewhat controversial evidence of their relationship (Cerin et al., 2009; White et al., 2017). This finding highlights the need for more extensive investigations of occupational PA in order to determine when it may beneficial to mental well-being. Occupational PA is likely to be viewed as a compulsory task rather than voluntary activity and not providing opportunities for enjoyment, mastery or improved self-esteem, thereby not improving mental well-being.

Another interesting finding in our study is the positive association between commuting PA and high PMH. In our study, commuting PA included travel on foot, by bicycle or similar 30 min or more per day to and from work or school. Relatively few studies have explored these associations showing to some extent conflicting results (Humphreys et al., 2013; Mytton et al., 2016). However, our observation mirrors those that have found a positive relationship between commuting PA and mental well-being (Martin et al., 2014; Mason et al., 2016; Mytton et al., 2016; White et al., 2017). Our study was cross-sectional and therefore does not allow for an understanding of the temporal associations between commuting PA and PMH. Nonetheless, perhaps walking or cycling to school or work creates feelings of enjoyment and mastery similar to those argued with leisure time PA. This could imply that policy actions such as city planning to develop and provide safe pedestrian and cycle paths to encourage active commuting, and active leisure time for that matter, may be beneficial to PMH. Incentives at workplaces such as showers and storage facilities to promote and encourage active commuting including walking and cycling to work could also contribute to better mental well-being of employees.

A note on the possible direction of the association between PA and PMH is needed here. As our study was cross-sectional in design, we were not able to determine the causality or direction of the relationship between PA and PMH. Little potential evidence exists on the causal direction between PA and PMH (e.g. Harris, 2018) due to cross-sectional nature of the studies (e.g. Mason et al., 2016; Richards et al., 2015). There is, however, some evidence of bidirectional relationship between PA and mental ill-health, and a stronger suggestion of a potential causal relationship between PA and a reduced risk for depression (Choi et al., 2019; Pinto Pereira, Geoffroy, & Power, 2014; Schuch et al., 2018) the latter proposing a possible protective role of PA against depression. Interestingly, some studies have speculated that associations with low PMH mirror those of mental ill-health (Stewart-Brown et al., 2015; Stranges et al., 2014; Taggart et al., 2016). This suggests that at least with relation to low PMH, PA could provide protection against low PMH. Further, if the relationship between PA and PMH would potentially be bidirectional, such as suggested between PA and mental ill-health, low PMH could possibly result in lower levels of PA. Associations with high levels of PMH, on the other hand, have found to follow a different pattern to those of low PMH (Stewart-Brown et al., 2015). The mechanisms and explanations of possible causalities between PA and PMH lay beyond this current study, thus future inquiries and experimental research designs are needed.

It is also worth to bear in mind, that there are many factors that may influence PMH, PA being potentially one of them. Our study found higher levels of PMH generally among those respondents, who were older, higher educated, had high household income and perceived their health as good. It seems, therefore, that the relationship between PA and PMH is a complex one. We may need to look at other, potentially mediating or moderating factors such as socioeconomical factors, and what kind of role they play in the relationship between PA and PMH.

Nevertheless, our findings further strengthen the evidence of the positive relationship between PA and PMH. Population strategies to promote and support active lifestyles are necessary. Actions such as creating affordable leisure time PA opportunities for all and building PA promoting living and commuting environments are a recommended way to increase the activity levels of the population. In addition, community level measures such as easily accessible community PA groups and paid/volunteer PA guides could promote PA levels especially among those who are physically least active.

4.2. Study strengths and limitations

A major strength of this study is that it relies on a large, nationally representative sample of the population, which provides sufficient statistical power to distinguish associations between PA variables and PMH. Further, a well-established and validated measure, the WEMWBS, was used in the survey to measure respondents' PMH which benefits this study. The large sample size together with the use of a recognized measurement enables comparisons with findings of other studies in the same research area. In addition, the scope of the FinHealth 2017 Study allowed us to examine various domains of PA in addition to total PA levels. We were able to improve the representativeness further by using versatile information from national administrative registers to calculate survey weights that were used to adjust for non-participation.

Nevertheless, the study has some limitations. First, due to the cross-sectional nature of the study, no causal directions could be established from the observed relationships. Second, the survey respondents self-reported their PA levels, which may have led to overestimation of their activity levels. Objectively measured PA levels tend to be lower than subjective assessments of actual activity levels (Choi et al., 2019; Craig, Mindell, & Hirani, 2009). However, the PA measures used in the survey are widely used in large population-based studies (Strath et al., 2013) and have shown good psychometric properties (Fagt et al., 2011; Grimby et al., 2015; Hu et al., 2007). Third, the Finnish and the Swedish versions of the WEMWBS used in the survey have not yet been validated. Nevertheless, the short version of the scale, SWEMWBS, has been validated in Swedish (Haver, Akerjordet, Caputi, Furunes, & Magee, 2015). Further, the WEMWBS was translated from English into Finnish, and then independently back-translated to ensure that the content and meaning remained unchanged (language equivalence) (Beaton, Bombardier, Guillemin, & Bosi-Ferraz, 2000). The Swedish version of the WEMWBS was developed similarly. Finally, although the study population consisted of a nationally representative sample of adults over 18 years of age, care must be taken to generalise the study results to younger population or to populations of different nature.

5. Conclusion

This study highlights the importance of PA with relation to PMH among adults. Especially physical inactivity was strongly associated with low PMH. As low levels of PMH can potentially present a risk for mental ill-health, it seems vital to promote and increase PA among the least active population. However, as the causal direction between PA and PMH remains unsolved, future experimental research designs are needed to investigate the relationship further, including the direction of causation between these two domains. In addition, more information and deeper understanding, for example using qualitative methods, on the relationship and potential mechanisms between PA and PMH is warranted.

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Declaration of competing interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mhpa.2020.100319.

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