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The Moderating Effect of Personality on the Relationship Between Objectively Measured Physical Activity and Depression and Anxiety Among Adolescents: Results From the Tromsø Study – Fit Futures

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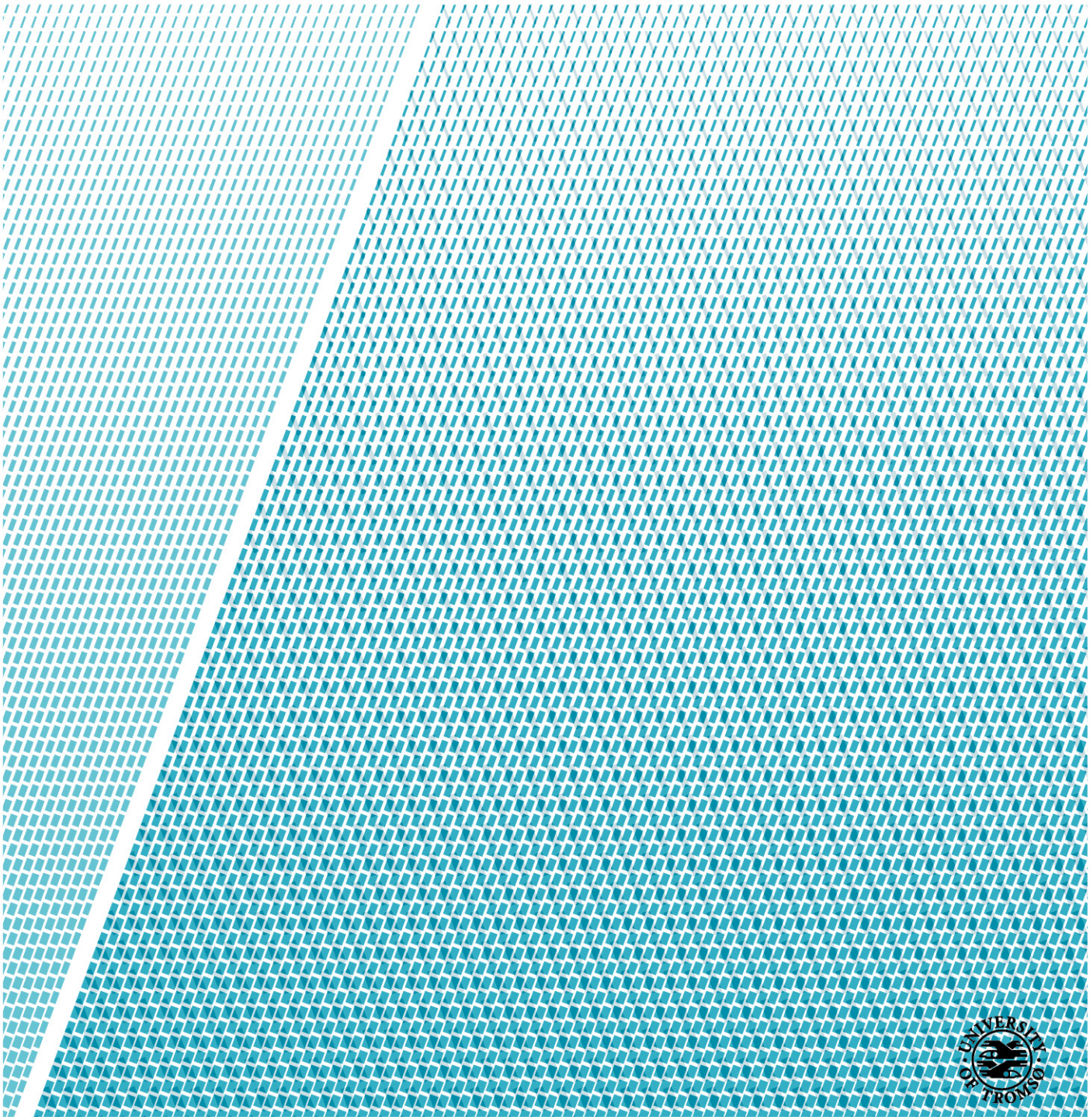

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Abstract

The purpose of this study was to examine the relationships between physical activity, personality and mental distress in an adolescent sample. We also investigated if the relationship between physical activity and mental distress is dependent on personality. Analyses were based on data from the second wave of the Tromsø study – Fit Futures. An objective measure of physical activity was used, in addition to self reports on physical activity, mental distress, and personality. 366 participants (233 female and 133 male) were included in the analyses (M_{age} = 18.52, *SD* = 1.75). Separate multiple hierarchical regression analyses were conducted for each personality trait to determine whether the trait had a moderating effect on the relationship between physical activity and depression. Results identified a possible negative interaction between steps per day and low scores on Neuroticism. A negative interaction between steps per day and high scores on Conscientiousness was also found. However, the results were uncertain and this was discussed. Because personality is fluctuating, and because many factors may contribute to the effect of physical activity, further research using objective measures are needed. Conclusions: Our results indicated that physical activity was not related to mental distress, except perhaps for participants low in Neuroticism and high in Conscientiousness.

Keywords: Physical activity, adolescents, mental distress, personality

Preface

This article is written as a main thesis for the last year of clinical psychology at UiT, The Arctic University of Norway. Data in this study was based on the Fit Futures study, which is part of the Tromsø Study (Tromsøundersøkelsen). A project sketch and publication plan for use in our application for permission to use data from the Fit Futures 2 (FF2) was written in the spring of 2018. The project was granted permission to data on the 30.10.2018, and is part of a research project (EUTRO-number 2620.00032) and a Ph.D-project (EUTRO-number 8040.00014) funded by Helse Nord. It has also been approved by the Data and Publications Committee (Data- og publikasjonsutvalget) for the Tromsø study. The authors have contributed equally to this thesis. Statistical analyses were conducted under the guidance of associate professor Kamilla Rognmo, and interpretations of results were discussed with her. We want to express our gratitude to Kamilla Rognmo and Ida Marie Opdal for their support and help in this project, as well as to each other for the teamwork.

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Depression and anxiety are two of the most common mental illnesses in Norway, and depending on their severity, they can drastically compromise the quality of life for those afflicted (Reneflot et al., 2018, p. 21; Bang Nes & Clench-Aas, 2011). It is estimated that approximately one fifth of the Norwegian population will develop a depressive disorder at some point in their life, and one in ten will suffer from depression over a 12 month period. The prevalence of anxiety is similar, as approximately one quarter of the Norwegian population will develop an anxiety disorder at some point in their life, and around 15 percent will have such a disorder within a period of 12 months (Reneflot et al., 2018, p. 30). The age of onset for symptoms of depression and anxiety is often during adolescence, which makes adolescents important targets of preventive measures (Kessler & Bromet, 2013, p. 5; Reneflot et al., 2018). Reneflot et al. (2018) also report that levels of comorbidity between anxiety and depression in children and adolescents in the Norwegian population are found to be high, and that twice as many women in Norway suffer from depression and anxiety compared to men. Studies on adult populations also find women to show more symptoms of depression and anxiety (Weissman et al., 1996; Van De Velde, Bracke & Levecque, 2010; Bourdon, Boyd, Rae, Thompson, & Locke, 1998, Lewinsohn et al., 1998).

According to the International statistical classification of diseases and related health problems (ICD-10), depression is characterized by low mood and reduction of energy, activity, concentration, interest in sex, and ability to feel joy and interest. Poor sleep, tiredness, changes in appetite, reduced self-esteem and feelings of guilt are also common. Anxiety is characterized by unfounded fear of one specific object or situation, or of several

unspecific situations, accompanied by mental and autonomous reactions such as avoidance, worrying, increased heart rate, and sweating (ICD-10, 2007).

Knowledge of the underlying mechanisms of depression and anxiety, and the factors which affect their development, is crucial for effective prevention and treatment. Several factors, such as physical activity, have been found to correlate with the presence of depressive symptoms and symptoms of anxiety (Mammen & Faulkner, 2013, p. 651; Petruzzello, Landers, Hatfield, Kubitz & Salazar, 1991, p. 156).

Physical activity

By physical activity, we mean all muscle movement resulting in increased energy expenditure (Bahr, 2009). Physical activity improves endurance and strength, and can help prevent overweight. It can also contribute to beneficial health outcomes such as increased well being and self-esteem, and improved quality of sleep and cognition (Berg & Mjaavatn 2009, p. 48; Henriksson & Sundberg, 2009, p. 27).

It is generally recommended for children and adolescents to be physically active for 60 minutes every day, and intensity should be medium or above in order to obtain the previously mentioned health benefits of exercise, as well as for adequate child development to occur (Helsedirektoratet, 2014). For adults, the recommended minimum is 30 minutes per day (Jansson & Anderssen, 2009, p. 39). A four year longitudinal study on 992 Norwegian 15-year olds, in which physical activity was objectively measured by the ActiGraph, showed that only 50% of the girls and 54% of the boys met the recommended level of activity for children and adolescents. Girls were less active than boys, and physical activity decreased with increasing age (Anderssen, Kolle, Steene-Johansen & Andersen, 2008). These findings imply that a large proportion of Norwegian adolescents may not be sufficiently physically active to obtain the health benefits described above.

There is a negative correlation between age and physical activity, and adolescence is a period of life where many stop engaging in certain common types of leisure time physical activity (Kolle, Stokke, Hansen & Anderssen, 2011). Interestingly, as described above, this coincides with the period of life where mental distress often starts to appear (Kessler & Bromet, 2013; Reneflot et al., 2018).

Helgadottir, Forsell and Ekblom (2015) measured physical activity with accelerometers over one week in 165 participants aged 18 to 65, who had mild to moderate symptoms of depression and/or anxiety (operationalized as scores on MINI and MADRS). They found that participants with mild to moderate symptoms of anxiety and/or depressive disorders, were on average sedentary for nine hours per day – the majority of the time they were awake. One point increase in MADRS scores was associated with 2.4 minutes reduction of light physical activity, indicating that light physical activity might help reduce symptoms of anxiety and depression. They did not find significant reductions in mental distress in association to MVPA.

The study by Helgadottir et al. (2015) adds to a vast amount of research which has shown physical activity to have an inverse relation to symptoms of mental distress (e.g. Mammen & Faulkner, 2013; Petruzzello et al., 1991), leading to a general idea that physical activity has a positive effect on mental health. The nature of this relation is not entirely understood, but different hypotheses have been suggested.

One theory attempting to explain the relationship between physical activity and depression, is the protection hypothesis (Birkeland, Torsheim & Wold, 2009, p. 26). This hypothesis postulates that physical activity works as a protective mechanism against the development of mental illness. If such a hypothesis is correct, the effect that exercise can have on physiological responses offers a possible explanation: Physical activity leads to increased endorphin production and to an increase in release of affect-related monoamines such as

norepinephrine and serotonin. It can also affect perceived stress through changes in levels of stress related hormones. Alternatively, the protective effect could be a result of psychological changes, such as the positive impact of exercise on self-esteem, distraction from stressors and rumination, or it could be associated to the social aspects that are prominent in many forms of physical activity (Birkeland, Torsheim & Wold, 2009, p. 26).

An alternative theory of how physical activity and mental distress affect one another, is the inhibition hypothesis (Birkeland, Torsheim & Wold, 2009, p. 26–27). The inhibition hypothesis proposes a different relationship between mental distress and exercise: That symptoms of depression lead to reduction in energy and motivation which, in turn, makes the individual less likely to be physically active. Birkeland and colleagues also propose that the relationship may be bidirectional, in which case, the protection and the inhibition hypotheses could be simultaneously true (Birkeland, Torsheim & Wold, 2009, p. 27).

Birkeland and colleagues (2009) conducted a longitudinal study on 924 Norwegian adolescents aged 13 to 23 over a period of ten years, in which they used self report questionnaires to collect data on physical activity and depressive mood. They did not find prospective relations between physical activity and symptoms of depression, and therefore concluded that neither the protection or the inhibition hypothesis could sufficiently explain how physical activity and mental health varies together in an adolescent sample. This indicates that even though several studies, such as those mentioned above, have provided support that there is a relationship between these factors, the mechanisms behind this relationship are still not known.

Cross-sectional studies on the relationship between physical activity and mental distress. Most cross-sectional studies find evidence that physical activity may serve as a protective mechanism against the development of depression and anxiety. Motl, Birnbaum,

Kubik and Dishman (2004) collected data on leisure time physical activity (measured with self report) and depression (measured by scores on the Center for Epidemiological Studies Depression Scale, CES-D) through self report in 4,595 adolescents, and discovered a significant inverse relationship between physical activity and depression (Motl et al., 2004, p. 339). This was also true after controlling for factors such as gender, SES, and substance use. Furthermore, upon investigation of the effect of screen use and leisure time physical activity (measured by self report) on depression (measured by scores on the Short Mood and Feeling Questionnaire) in a population of 8,256 children and adolescents aged ten to 16, Kremer et al. (2014, p. 184–185) found that increased physical activity and decreased screen time were associated with a decrease in depressive symptoms.

Whereas these researchers only investigated how physical activity might affect depression, several other studies have investigated how it affects anxiety as well as depression. Moksnes, Moljord, Espnes and Byrne (2010), for instance, studied 1,508 Norwegian adolescents aged 13 to 18 and found a weak but significant inverse relationship between leisure time physical activity (measured by self report) and both depression and anxiety (measured with the Adolescent Stress Questionnaire, State-Trait Anxiety Inventory and a non-clinical state depression questionnaire) (Moksnes et al., 2010, p. 19–20).

Bélair, Kohen, Kingsbury and Colman (2018, p. 2) found that in a sample of 9702 adolescents aged 14–15, those who engaged minimally in leisure time physical activity (indicated by self report), reported higher symptoms of both depression and anxiety (measured with questions from DSM-III-R criteria for emotional disorders) compared with adolescents who reported at least one day of physical activity per week. Reviews conducted by Larun et al. (2006, p. 8) and Biddle and Asare (2011, p. 888–889) also show that there might be a small positive effect of physical activity on anxiety and depression.

Because cross-sectional studies can not provide information about the relation between physical activity and mental distress over time, or about how changes in physical activity levels may affect mental distress, we consulted the literature on longitudinal research on the relation.

Longitudinal studies on the relationship between physical activity and mental distress. In Mammen and Faulkner's (2013) systematic review, 25 out of the 30 prospective studies included demonstrated that baseline aerobic physical activity was inversely related to depression. Five studies found no such inverse relationship between depression and baseline physical activity, and four found this association for female participants, but not for males. 17 of the 25 studies that found this relationship were considered to be of high quality, and six of modest quality. Only one of the five studies that did not find this relationship were considered to be of high quality; four of them measured frequency, but not intensity of activity. Participants in all studies were non-clinical populations between 11 and 100 years of age; 20 studies had both female and male participants, five included only female and four included only male participants. Measures of depression included DSM-IV criteria, a variety of well-validated depression scales, and other indicators such as physician diagnosis and use of antidepressants. Weaknesses presented in this review include that studies varied in regard to measures of depression, which may complicate comparison of results of the studies included, and that only one study objectively measured physical activity (Mammen & Faulkner, 2013, p. 651–653). The review provides substantial support for the theory that physical activity may have a protective effect against the development of depression, but the authors note that the use of inconsistent self report measures means that the necessary amount of physical activity needed to achieve mental health benefits, could not be investigated in this study (Mammen & Faulkner, 2013, p. 654).

Norris, Carroll and Cochrane (1992, p. 61) measured mental distress, including symptoms of both anxiety and depression (operationalized as scores on the Multiple Affect Adjective Inventory), in 147 adolescent participants with a mean age of 14, before and after ten weeks of different exercise programmes. They found that anxiety levels decreased to a greater degree for participants who had engaged in a high intensity exercise programme, compared to participants who had exercised with moderate intensity. Objective measures such as aerobic fitness levels, blood pressure and heart rates were measured prior to the experiment, and compared with measures from after the exercise programmes. The researchers additionally found that more frequent physical activity was associated with lower levels of self reported symptoms of depression.

McKercher et al. (2009, p. 161–163) investigated effects of both self reported and objectively measured physical activity on clinical depression, measured with the Composite International Diagnostic Interview of the World Health Organization (CIDI) in 1,995 young adults aged 26 to 36. Self reported data on physical activity was collected through the International Physical Activity Questionnaire. Objective data was collected as participants wore a pedometer for seven days. They found that moderate levels of activity (7,500 steps per day or more) were associated with a lower prevalence of depression compared to sedentary behavior (less than 5,000 steps per day) in women. Even low levels of leisure time physical activity (1.25 hours per week or more) were associated with lower levels of depression compared to the sedentary group. However, high levels of physical activity at work (ten hours per week or more) were found to be associated with higher prevalence of depression, compared with sedentary workers. An inverse association between depression and steps per day was also found for men, but this finding was not significant.

Other researchers have found less promising results regarding the relationship between physical activity and depression. For instance, Toseeb et al. (2014) used objective measures of

physical activity in a three year study on 736 adolescent participants with a mean age of 14.5 years, and found no relation between these variables. Furthermore, Rothon et al. (2010) found cross-sectional evidence that larger amounts of physical activity was associated with lower symptoms of depression (measured by the Short Moods and Feelings Questionnaire) in 2,789 adolescents, but they found no significant longitudinal association between physical activity and depressive symptoms. Van Dijk, Savelberg, Verboon, Kirschner and De Groot (2016) used objective measures to study the relation between mental distress and physical activity in 158 adolescents. They also found no change in mental health (measured by the CES-D) with decline in physical activity over a period of one year.

Hume et al. (2011) measured physical activity and sedentary behavior both cross-sectionally and longitudinally in 155 adolescents (aged 10 to 12 in 2004 and 14 to 15 in 2006). They found that physical activity (objectively and subjectively measured), organized sports and sedentary behavior, were unrelated to depressive symptoms (measured by the Center for Epidemiological Studies Depression Scale for Children, CES-DC) in both genders, thus finding no support for an inverse relation between these variables.

De Moor, Beem, Stubble, Boomsma and De Geus (2006) conducted a population based study in which the relationship between physical exercise and anxiety and depression was investigated over an 11 year period. Participants were 19,288 adolescent and adult twins and their families, voluntarily registered in the Netherlands Twin Registry. Data was collected every second year through self report questionnaires on lifestyle and health; no objective measures were used. Findings revealed that scores on depression and anxiety were lower among exercisers compared to the participants who did not exercise over the 11 year period. The differences between participants who did and did not exercise were found to be small, but consistent across both gender and age (De Moor et al., 2006, p. 274–275).

Larun, Nordheim, Ekeland, Hagen and Hein (2006), however, conducted a systematic review on 16 longitudinal RCT studies with a total of 1,191 child and adolescent participants, and concluded that the majority of the studies investigating the relationship between physical activity and depression and anxiety, were not of high enough methodological quality to make a conclusion.

A systematic review of 10 studies (involving a total of approximately 25,000 participants) conducted by Bursnall (2014, p. 378–380) provided support for the likelihood of an inverse relationship between physical activity and depressive symptoms in adolescent populations. Eight of the studies included in this analysis (four longitudinal and four cross-sectional cohort design studies) found a significant and consistent inverse relationship between physical activity and symptoms of depression over time. The remaining two studies (one quasi-experimental design and one high quality RCT, in which some of the participants were not adolescents), also found a decrease in depressive symptoms in response to increased physical activity. A mix of studies using self report and objective measures were included.

Furthermore, Calfas and Taylor (1994) conducted a review of 20 studies (participants aged 11–21) aiming to identify the nature of the relationship between physical activity and both depression and anxiety (as defined in the DSM-III-R). Physical activity was related to improvement in both symptoms of depression and anxiety in most studies, but the methodology and design of the studies included in this review were also varied. Some found less support for reduction of mental distress, but the researchers pointed out that no studies found negative effects of physical activity on anxiety, depression or other mental distress outcomes, and all nonsignificant results also pointed in the direction of symptom reduction (Calfas & Taylor, 1994, p. 218).

Summary of findings on the relation between physical activity and mental distress. In summary, prospective studies show mixed results regarding the effect of physical activity on symptoms of depression and anxiety. The majority of them find some support for an inverse relationship between the two (Mammen & Faulkner, 2013; Bursnall, 2014; Calfas & Taylor, 1994; De Moor et al., 2006). Some find no support for an inverse prospective relationship (Toseeb et al., 2014; Hume et al., 2011; Rothon et al., 2010), and others find that the inverse relationship is significant in women, but not in men (Mammen & Faulkner, 2013; McKercher et al., 2009).

Results are less ambiguous among cross-sectional studies: Inverse effects are found in studies investigating the association between physical activity and depression (Motl et al., 2004; Rothon et al., 2010; Kremer et al., 2014), and in studies investigating the association between physical activity and depression and anxiety (Moksnes et al., 2010; Larun et al., 2006; Biddle & Asare, 2011; Bélair et al., 2018; Norris et al., 1992). A shortcoming of cross-sectional studies is that they can not provide insight on causation (Biddle & Asare, 2011; McKercher et al., 2009). Furthermore, some of the researchers mentioned above state that there is insufficient evidence to make conclusions in adolescent populations based on their investigations (Larun et al., 2006; Biddle & Asare, 2011). Also, the majority of these studies must be interpreted with caution due to methodological weaknesses, for instance that studies are largely based on self report (Mammen & Faulkner, 2013; Larun et al., 2006).

Possible explanations for differences in results

As described above, there is now substantial support for an inverse relationship between physical activity and symptoms of depression, but many studies do not find similar results. This is particularly true for studies on adolescent populations; specifically, cross-

sectional studies tend to find support for such a relation in adolescent samples, whereas prospective studies sometimes do not.

A possible explanation for the differences in results across studies, regards the modes of measurement applied in existing research: Studies are based largely on subjective self report measures, which tends to give different results than objective measures (Slootmaker, Schuit, Chinapaw, Seidell & van Mechelen, 2009). Self report has been found to give false estimates of physical activity (Rzewnicki, Vanden Auweele & De Bourdeaudhuij, 2003; Prince et al. 2008). This means that results from studies which rely on self report might have limited validity. Several of the studies which do find support that physical activity decreases mental distress described above, rely on self report for both depression, anxiety and physical activity. It could be that people who do not suffer from substantial symptoms of depression and anxiety might have an excessively optimistic view of their own tendency to engage in physical activity, whereas people with depressive and anxiety symptoms might underestimate their levels of physical activity. People from healthy populations tend to think of themselves as more active than they really are (Groven-Robertsen, 2016; Sallis & Saelens, 2000), and studies also show that teenagers and people with higher proportions of body fat tend to overestimate their own levels of physical activity. In addition, memory, interpretation and social factors can all influence self report replies (Slootmaker et al., 2009; Buchowski, Townsend, Chen, Acra & Sun, 2012).

Differences in results could alternatively arise from age-related changes in both psychological and physiological factors. One such factor is personality.

Personality and mental disorders

Personality is known to be associated with symptoms of depression and anxiety. Personality is a pattern of behavior and cognition which is considered to be relatively stable

across time and situations, and which differs from one person to another (Martin, Carlson & Buskist, 2013, p. 554). One of the most widely acknowledged models of personality is the Big Five, also known as the five factor model of personality (FFM; McCrae & Costa, 1987), in which personality is measured according to scores on factors, or traits, labelled Neuroticism, Extraversion, Openness to experience, Conscientiousness and Agreeableness. The FFM covers both normal and abnormal personality traits, and has been found to describe a universal structure of personality dimensions (Costa & McCrae, 2008, p. 224). According to Costa and McCrae (2008, p. 192), their traits have been found to be hereditary and stable across both age and culture. Research on the association between personality and mental distress is largely based on this model (e.g. Wilson & Dishman 2015; Soto, John, Gosling and Potter, 2011).

Assessment tools for measurement of the Big Five personality factors include McCrae and Costa's Neuroticism, Extraversion and Openness Personality Inventory, which exists in various versions. The NEO Inventories map the respondent's scores on 30 different personality traits, which constitute each of the five factors. The inventories are extensively validated, and intended for both clinical and research use (Costa & McCrae, 2008). Another measure of personality based on the Big Five personality theory, is the Big Five Inventory (BFI). The BFI is a self report inventory consisting of 44 questions from which a score on each of the five personality factors is calculated (John & Srivastava, 1999). The BFI has been found to show adequate reliability in a non-clinical adult population, and reasonable validity in relation to peer ratings and other instruments based on the Big Five (John & Srivastava, 1999, p. 22–26). Soto et al., (2011, p. 331) state that previous research has shown that also youth's self report responses on Big Five traits are valid.

Several theories suggests that personality can be explained by three factors (e.g. Eysenck and Eysenck's model developed in the early 1970's; Clark & Watson, 1999). The

model proposed by Eysenck and Eysenck, includes the traits Extraversion versus Introversion, Neuroticism versus Emotional stability, and Psychoticism. In Clark and Watson's three factor model, the traits are labelled Negative emotionality, Positive emotionality and Disinhibition versus constraint. According to Clark and Watson, their traits are highly correlated with those of Eysenck and Eysenck (Clark & Watson, 1999, p. 269), with Neuroticism overlapping with Negative emotionality, and Extraversion overlapping with Positive emotionality. Psychotisism and Disinhibition versus constraint are also closely related, but to a somewhat smaller degree. The frequently used Eysenck Personality Questionnaire (EPQ) and the General Temperament Survey are developed to measure the three dimensions (Russin & Codon, 2016; Clark & Watson, 1999, p. 269).

Kotov, Gamez, Schmidt and Watson (2010, p. 769–770) state that the Eysenck and Eysenck's three traits also largely overlap with the Big Five factor traits, with the exception of the Big Five trait Openness, which is found to be more or less unrelated to Eysenck and Eysenck's three traits. Disinhibition versus constraint is negatively correlated with the Big Five traits Conscientiousness and Agreeableness (Clark & Watson, 1999, p. 270), and Eysenck and Eysenck's original trait Psychoticism represents disinhibition versus constraint (Kotov et al. 2010).

Research on the link between personality and mental distress. Two large reviews have been conducted in order to summarize the findings of existing research on the relationship between personality and mental distress. Kotov et al. (2010) conducted a review of 175 studies published between 1980 and 2007, investigating the associations between personality traits (from the Big Three and Big Five models) and both depression and anxiety in adult samples. Participants in the studies which were included in the analysis, were recruited from both normal and clinical populations with disorders characterized by

depression and anxiety. The researchers found that high scores on the trait Neuroticism and low scores on Conscientiousness characterized participants with elevated scores on all categories of depression and anxiety. Low scores on Extraversion were additionally found in many of the depressive and anxiety disorders. Agreeableness and Openness were found to be largely unrelated to depression and anxiety. Surprisingly, only a weak link was identified between major depressive disorder and Extraversion. Higher scores on Disinhibition was also common in several disorders of anxiety and depression (Kotov et al., 2010, p. 803). Most types of depression and anxiety related disorders were highly correlated to Neuroticism. Out of the different anxiety disorders, only social anxiety is found to correlate significantly to Extraversion (Kotov et al., 2010, p. 770).

Similar results were discovered by Malouff, Thorsteinsson and Schutte (2005, p. 101) in a meta-analysis of 33 studies, in which the relationship between the Five-Factor model of personality and symptoms of clinical disorders were investigated. This analysis additionally showed low Agreeableness to be linked to symptoms of clinical disorders. Their analysis included 17 correlational studies, in which it was found that high scores on Neuroticism and low scores on Extraversion, Conscientiousness and Agreeableness constituted a typical personality profile across symptoms of Axis 1 clinical disorders described in the DSM-IV-TR (including depression and anxiety). Openness was not found to be associated with symptoms of the disorders.

Previous research on the relationship between personality and psychiatric disorders in Norwegian populations, includes a twin study recently published by Rosenström et al. (2018). Their research was based on data collected over a period of five years on 2,801 Norwegian twins aged 19 to 46, in addition to a re-interview on 2,284 of the participants 10 years later. CIDI (Structured Interview for DSM-IV Personality) and parts of ICD-10 were used as interviews to measure pathology. The BFI was used to assess normative personality, and the

personality inventory in DSM-5 (PID-5-NBF) to measure the following maladaptive, or pathological, personality traits: Negative emotionality (defined as the opposite of emotional stability), detachment (in contrast to extraversion), antagonism (in contrast to agreeableness), disinhibition (in contrast to conscientiousness), and psychoticism (in contrast to lucidity). They found one general risk factor for all psychopathology, which loaded heavily on all 11 mental illnesses included in the study, as well as on the PID-5-NBF. It also loaded inversely on the normative personality traits in BFI, except from Openness. This factor had an estimated heritability of 48%. Another risk factor for internalizing disorders and traits (such as depression and anxiety) was found, as well as a third factor for externalizing disorders and traits (such as substance use and antisocial personality). The results imply that personality pathology, together with general psychopathology, might have a common genetic etiology.

Personality and physical activity

Personality has also been shown to be associated with physical activity: De Moor et al. (2006, p. 275) discovered that participants who engaged in exercise had lower scores on Neuroticism, and higher scores on Extraversion and Sensation seeking (traits from the Amsterdamse Biografische Vragenlijst, based on the EPQ). Furthermore, in their systematic review and meta-analysis of 64 studies which all included Big Five personality measures, Wilson and Dishman (2015, p. 233) found that high scores on Extraversion, Openness, and Conscientiousness, and low scores on Neuroticism, significantly correlated with a larger degree of engagement in physical activity among participants. Agreeableness was only significantly related to physical activity in participants aged 35 and older. The analysis included 64 studies (both longitudinal and cross-sectional) with a total of 88,400 participants aged 14 to 92. Nine out of 64 studies included objective measures of physical activity,

whereas 52 used unvalidated self report measures. The researchers recommended that future studies apply objective measures of physical activity (Wilson & Dishman, 2015, p. 240) .

Changes in personality across the lifespan

Several studies have highlighted how personality tends to change with age. For instance, Soto et al. (2011) conducted a large, Internet based cross-sectional study including 1,267,218 participants aged 10 to 65 years, to investigate patterns of personality in different age groups. Personality was measured through self reports on the BFI. They found a clear tendency for decrease in Conscientiousness from childhood into adolescence, which switched to an increase from adolescence into – as well as across – adulthood. The increase was slightly larger for women compared to men. The pattern was similar for Agreeableness, but increases on this trait were smaller than for Conscientiousness. Females reported higher scores on Agreeableness across all age groups (Soto et al., 2011, p. 337–338). For Neuroticism, scores increased from childhood into adolescence, and remained stable before decreasing by middle age for women. For men, Neuroticism scores decreased somewhat from late childhood into middle age. Extraversion scores decreased from late childhood to adulthood, and further into middle age. Openness decreased from late childhood into early adolescence for both genders, and further throughout adolescence for females. From then on into middle age, there was an increase (Soto et al., 2011, p. 338–340). Thus, age differences were largest on Agreeableness and Conscientiousness, and gender differences were found on scores on Neuroticism and Openness. Similar findings were reported by Roberts and Mroczek (2008).

Donellan and Lucas (2008) also found that Extraversion declined with age and that Agreeableness increased with age, whereas Conscientiousness levels were highest for participants in middle age. Unlike Soto et al. (2011) and Roberts and Mroczek (2008), they

found Openness to decrease over time. These studies suggest a pattern of Agreeableness and Conscientiousness increasing, and Neuroticism, Extraversion and Openness decreasing after adolescence (although Neuroticism and Openness increases during adolescence).

The current study

The purpose of this study was to examine the relationship between physical activity and mental distress, and between personality and mental distress in an adolescent sample, and to investigate if the relationship between physical activity and mental distress is dependent upon personality. Increased knowledge on this relationship could make it possible to identify individuals who are likely to benefit from intervention programmes based on physical activity, thus facilitating the development of cost-effective programmes for prevention and treatment of mental health problems.

To our knowledge, only a few studies have previously investigated the complex association between personality, physical activity and symptoms of depression and anxiety (Brunes & Augestad, 2012; De Moor et al., 2006). The studies conducted by Brunes and Augestad and by De Moor and colleagues involved adult participants only, and used no objective measures of physical activity. Because objective measures and self report measures tend to give different results, we will apply both in our study in order to measure physical activity level as accurately as possible.

Whereas we will investigate personality as a moderator for the relationship between physical activity and mental distress, Yeatts, Martin and Petrie (2017) conducted a study in which they investigated physical activity as a moderator of the relationship between personality and mental distress in adolescents (M_{age}=12). Physical activity was objectively measured with tests on cardiorespiratory fitness (CRF), muscular strength, body composition and endurance. Their study showed that CRF had a moderating effect on the relationship

between Neuroticism and depression – individuals who had high scores on Neuroticism as well as on measures of CRF, had fewer depressive symptoms than those with lower scores. This study, in contrast to others (e.g. Helgadottir, Forsell & Ekblom, 2015) indicates that fitness levels, which results from relatively demanding physical activity, can help reduce depression.

Further research on the relationship between physical activity and mental distress is necessary in order to increase our knowledge and understanding of the underlying mechanisms of depression, anxiety and related mental health problems.

Methods

Design and sample

This study is based on data from the Tromsø Study – Fit Futures, a comprehensive examination of health among youth in Northern Norway. The Fit Futures study was first carried out in 2010 and 2011 (FF1), in which all first year upper secondary school pupils in the municipalities of Tromsø and Balsfjord in Troms county were invited to participate. 1,117 pupils were invited, out of which 1,038 (92,9%) agreed to participate. In the school year of 2012 to 2013, all third year upper secondary school pupils in the same area were invited to participate in the follow up study Fit Futures 2 (FF2). 870 pupils out of 1,129 who were invited, participated in the FF2. As personality was measured only in the FF2 study, we will only include data from FF2 in this study.

The 870 participants of the FF2 constitute 77% of the pupils who were invited. This is regarded as a good response rate, and our population is highly representative of Norwegian adolescents in general. Participants had a mean age of 18.52 (*SD* 1.75) when FF2 was conducted. 68% of the sample was 1,75 years from the mean age.

Out of the 870 participants in FF2, 504 has been excluded from our analyses due to missing variables which were needed. Participants who wore the accelerometer on the hip for a minimum of four days, ten hours a day, were included in our study. In total, 366 (42.07%) of the participants had no missing responses on relevant variables, and were included in the analyses. Out of the 366, 63.66% (233) were female and 36.34% (133) were male. Data was anonymized by the Tromsø Study before it was shared with the authors.

Measures

Physical activity. Objective data on the main predictor physical activity was measured by use of the ActiGraph GT3X accelerometer. This device is designed to measure number of steps and physical activity in counts which can be categorized into sedentary, light, moderate and vigorous activity. Emaus et al. (2010) showed that the ActiGraph provides more accurate measures of activity than self report questionnaires. Wetten et al. (2014, p. 642), however, found that the ActiGraph can underestimate cycling and unstructured activity energy expenditure.

Steps per day and *Minutes in moderate to vigorous activity per valid day* were used as main predictors in analyses. Two self report measures were included as covariates in the analyses: *Physical activity during leisure time* (1 = *sedentary* to 4 = *hard training several times a week*), and self reported *screen time* (which was calculated into one mean value from two questions – one for weekday and one for weekend). Screen time was treated as a continuous variable with seven categories (1 = no screen time, 2 = 30 minutes, 3 = 1–1,5 hours, 4 = 2–3 hours, 5 = 4–6 hours, 6 = 7–9 hours, 7 = 10 hours or more).

Mental distress. The outcome variable mental distress was operationalized as symptoms of depression and anxiety, measured by the Hopkins Symptom Checklist-10

(HSCL-10). HSCL-10 consists of 10 items, and is a well validated measure of symptoms of depression and anxiety (Derogatis et al., 1974 p. 9–13; Haavet et al., 2011, p. 236). Four of the items measures symptoms of anxiety and six items measures symptoms of depression. Questions are answered on a scale from 1 to 4: *No, Slightly, Much* and *Very much*. For analyses in this article, HSCL-10 variables were computed by calculating the mean of all 10 HSCL-10 questions, giving each participant a mean score.

For people aged 15 and older, a cut-off at 1.85 is suggested as a good prediction of whether the symptoms indicate mental illness (Strand, Dalgard, Tambs & Rognerud (2003, p. 117). For adolescents, Sirpal, Haugen, Sparle and Haavet (2016) suggests a cut-off point of 1.6. A cut-off point of 1.80 was used in our analyses; this was considered appropriate because the participants in this study had a mean age of 18.52, which can be considered an age in between adolescence and adulthood.

Covariates

Personality. The FF2 included the 44 item BFI personality measure, with response categories ranging from 1 = *Disagreeing very much* to 6 = *Agreeing very much.* For analyses, each of the five personality factors was split into three groups of approximately 33%, labeled as low, medium and high scores.

Demography. Questions on gender and age were included.

Health, social network and lifestyle. Body mass index (BMI) was calculated from measures of weight and height: Weight in kilograms divided by the square value of the height in meters. BMI can be a good estimate for health in a population, but it does not take the nature of an individual's fat distribution into account (WHO 2000, p. 9). WHO (2000, p. 9)

has classified a BMI of <18.5 as underweight, 18.5–24.9 as normal weight, 25.0–29.9 as overweight, and 30.0 and above as obesity.

It has been shown that satisfaction with social network can have an impact on health (Currie et al. 2010, p. 79). Additional variables considered relevant to our study include subjective perception of health *("How do you in general consider your own health to be?"* rated on a five point scale from *Very bad* to *Excellent*) and satisfaction with social network *("I find it quite hard to make friends", "I have many friends", "My peers don't like me"*, *"I am popular among my peers", "I feel that my peers accept me"*, indicated on a four point scale from *Highly incorrect* to *Highly correct*); statements included in order to indicate satisfaction with social network were calculated into one mean variable.

Smoking habits *("Do you smoke?")*, indicated on a four point response range from *Never* to *Daily*, were included. Alcohol use *("How often do you drink alcohol?","If you drink alcohol, how many units of alcohol (a beer, a glass of wine or a drink) do you usually drink when you drink alcohol?", "If you drink alcohol, how often do you drink 6 units alcohol or more in one occasion?")* rated on five point scales, was converted into a single sum score for alcohol intake, ranging from one to 15, where higher scores indicated higher consumption. This sum score was also included in the analyses. Smoking habits and alcohol use were measured as they have been linked to health in several studies (Loef & Walach, 2012).

Analytical strategies

Probabilities of $p \leqslant 0.05$ were regarded as statistically significant. Analyses were conducted with SPSS version 25 (IBMCorp, 2017).

Descriptive statistics. Descriptive statistical analyses were conducted. These included means and standard deviations for men and women separately, and for both genders

combined. Descriptive statistics for the genders separately were found by splitting the data file according to gender in SPSS. Seven participants were tested in summer, the remainder was tested in the winter.

Correlation. A correlation analysis was conducted between the physical activity variables steps per day and moderate to vigorous physical activity in minutes per day, HSCL-10, and Big Five personality traits.

Regression. Separate hierarchical multiple regression analyses were conducted to investigate the main effects of physical activity and personality on mental health, and to investigate potential moderating effects of each Big Five personality trait on the relationship between physical activity (operationalized as steps per valid day and moderate to vigorous physical activity in minutes per valid day) as predictor variables, and mental distress (operationalized as symptoms of depression and/or anxiety as reported on HSCL-10) as the outcome variable. Covariates were included hierarchically in five blocks: In the first block, we entered one of the objectively measured physical activity variables and one of the categorical personality trait variables; in the second block, the interaction effect between these variables was entered. A third block added the demographic variables sex, age at screening, and season at screening. Next, we included a fourth block with the variables BMI, alcohol use, smoking, social network and subjective perception of health. Finally, the fifth block included self reported physical activity during leisure time (over the previous year), as well as mean screen time per day.

Separate analyses were then carried out for each of the five traits to investigate the potential moderating effect of each personality trait on physical activity and interaction effects between a given trait and the two measures of physical activity (steps and MVPA). This

procedure was repeated for each of the ten combinations of traits and physical activity measures. For significant moderating effects, additional analyses were carried out to investigate simple effects.

Results

Descriptives

Table 1 shows the mean scores on relevant covariates for our sample.

Symptoms of depression and anxiety. As shown in Table 1, the mean score on HSCL-10 for women was somewhat higher compared to men (M = 1.66 and M = 1.39, respectively). Average scores on symptoms of depression and anxiety were below the cut-off at 1.80 for indication of clinical disorder. 23.8% of the sample had HSCL-10 scores above cut-off.

Health and substance use. Mean scores showed that both men and women in this sample generally evaluated their own health as good. Mean score on self-reported health was 3.86 out of five in female participants, and 3.83 for men. Mean BMI for women was 23.13, whereas it was 23.56 for men. Average scores indicated that smoking was relatively uncommon for both men and women, but the prevalence was slightly higher for men (M = 1.60 out of four and 1.43, respectively. Mean score on alcohol use for women was 6.91 out of 15, and mean for men was 7.44, which can be considered a medium-sized tendency for alcohol use.

Lifestyle/physical activity. Participants reported themselves to be low to moderately active, with a sample mean for Leisure time physical activity of 2.45 out of 4, (*SD* = 0.91).

Accelerometer measures of steps per day showed that the mean value for women was 7,250 steps, and that the mean for men was 6,967 steps. Objectively measured moderate to vigorous physical activity (MVPA) showed that participants were fairly active (total sample mean = 35.83 minutes), but that there was large variation within the sample (*SD* = 19.41). Screen time mean for the total sample was 4.33, which indicated that average screen time was somewhere between 2–3 hours and 4–6 hours per day.

Other covariates. Mean satisfaction with social network for women was 3.18 out of 4, 3.26 for men, and 3.21 for the total sample. This shows that participants in general were highly satisfied with their social network.

Table 1
Descriptives of Covariates

	Women		Men		Total	
	M	SD	M	SD	M	SD
HSCL-10 (1–4)	1.66	0.56	1.39	0.46	1.56	0.54
Smoking (1 = never to 4 = daily)	1.43	0.81	1.60	0.98	1.49	0.88
Self-reported health (1 = bad to 5 = excellent)	3.86	0.71	3.83	0.79	3.85	0.74
Physical activity during leisure time (1 = sedentary to 4 = hard training)	2.43	9.83	2.42	1.02	2.43	0.91
Steps per day	7249.64	2172.05	6966.95	2577.00	7146.91	2327.85
Moderate to vigorous activity (minutes per day)	34.70	18.21	37.79	21.27	35.83	19.41
Screen time (1–7)	4.20	0.83	4.56	1.04	4.33	0.93
Social network satisfaction (1–4)	3.18	0.53	3.26	0.46	3.21	0.51
Neuroticism (1–6)	3.27	0.87	2.69	0.80	3.06	0.88
Conscientiousness (1–6)	4.17	0.74	4.03	0.71	4.12	0.73
Extraversion (1–6)	3.92	0.80	3.93	0.81	3.93	0.80

Openness (1–6)	3.85	0.81	4.03	0.77	3.91	0.80
Agreeableness (1–6)	4.50	0.76	4.35	0.69	4.45	0.74
BMI	23.13	3.98	23.56	3.89	23.29	3.95
Alcohol use (1 = low to 15 = high)	6.91	2.60	7.44	2.83	7.10	2.69

Note. M = Mean. SD = Standard Deviation. Women: N=233; men: N=133; total N=366. Mean age at screening = 18.52, SD 1.75.

Table 2 shows pearson correlations, which indicated a significant positive relationship between steps and Extraversion. Nonsignificant negative correlations were found between HSCL-10 and steps and between HSCL-10 and MVPA.

Table 2
Correlations for physical activity variables, personality trait variables and HSCL-10 scores

	Neuroticism	Conscien-tiousness	Extraversion	Openness	Agreeable-ness	HSCL-10
Steps	-.07	.07	.12*	.09	.08	-.046
MVPA	-.07	-.02	.01	.08	.02	-.063

Note. N=366. Steps = steps per day (1000), MVPA = moderate to vigorous physical activity in minutes per day. * = $p < 0.05$ (2-tailed).

Regression

A multiple hierarchical regression was calculated to predict HSCL-10 scores based on physical activity variables, personality trait variables, interaction effects of physical activity and personality and confounding variables. Ten analyses were conducted; the results are listed in tables 3–7.

Steps had a significant positive main effect on mental distress in models 4 and 5 of the analysis involving the personality trait Neuroticism. MVPA did not significantly predict mental distress in our sample.

Significant relations were found between personality and mental distress. Regression analyses revealed significant negative main effects of Extraversion on mental distress. The

effects were significant up to model 3 with both steps and MVPA as physical activity variables. No significant effects were found in models 4 or 5. Furthermore, analyses revealed significant positive main effects of Neuroticism on mental distress in all models.

Significant interaction effects between physical activity and personality trait variables on mental distress, were found between steps and Neuroticism, and between steps and Conscientiousness. First, as shown in Table 3, a significant negative interaction was found between steps and Neuroticism on HSCL-10 scores (B = -.024, p = .046). The file was split by Neuroticism in order to investigate simple effects; the result is displayed in Figure 1. No significant effect was present in either group in the simple effects analysis: Nonsignificant positive relations between steps and mental distress were found in the groups of participants with low (B = .014, p = .073) and moderate (B = .006, p = .705) scores on Neuroticism, while a negative nonsignificant relation between steps and mental distress was found in the group with the highest level of Neuroticism (B = -.034, p = .197). The effect was borderline significant in the third block (adjusting for age, sex and season at screening) for the low Neuroticism group (B = .017. p = .052), and in the fourth block (additionally adjusting for BMI, alcohol use and smoking, social network and subjective perception of health) in the moderate Neuroticism group (B = .032, p = .055). These borderline significant effects most likely caused the significant value found between steps and Neuroticism in our initial analysis.

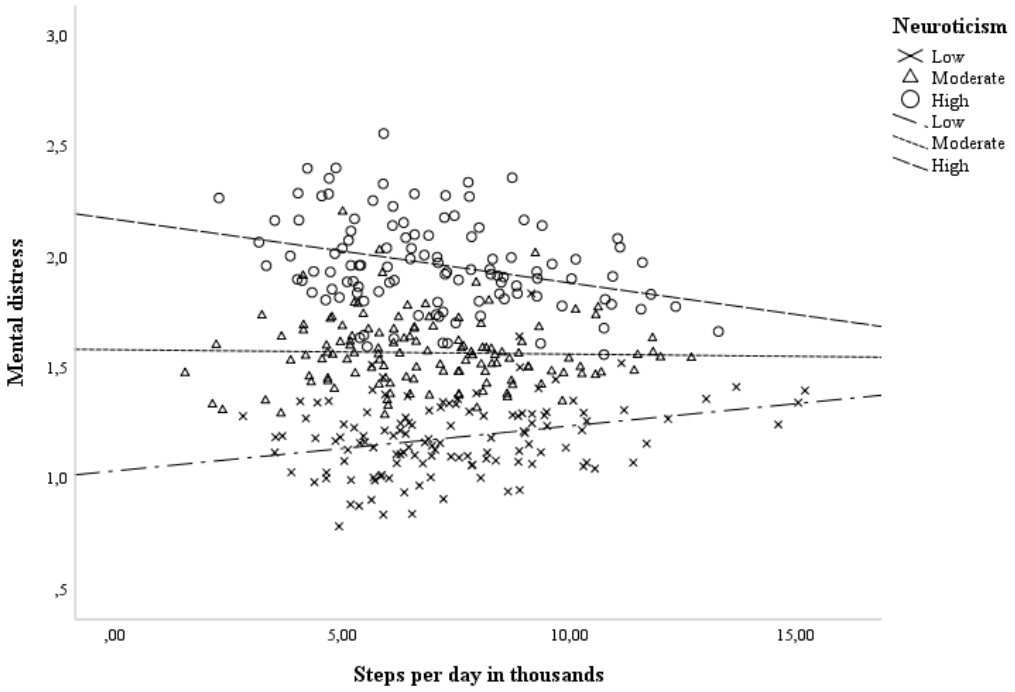

Figure 1. The relationship between steps per day, mental distress and Neuroticism.

Second, as shown in Table 4 , analysis of the relationship between steps and Conscientiousness uncovered a significant negative interaction effect on HSCL-10 scores (B = -.004, *p* = .000) in model 2, indicating that scores on this trait may moderate the effect of steps on mental distress. However, this effect was no longer present as additional covariates were adjusted for in subsequent models. Furthermore, no significant effects were found in simple effects analysis: In the unadjusted analysis, a negative, borderline significant relation appeared between steps and mental distress in the high Conscientiousness group (B = -.031, *p* = .055); non-significant negative relations were found between steps and mental distress in the participant groups with low (B = -.037, *p* = .183) and moderate (B = -.009, *p* = .595) scores on Conscientiousness.

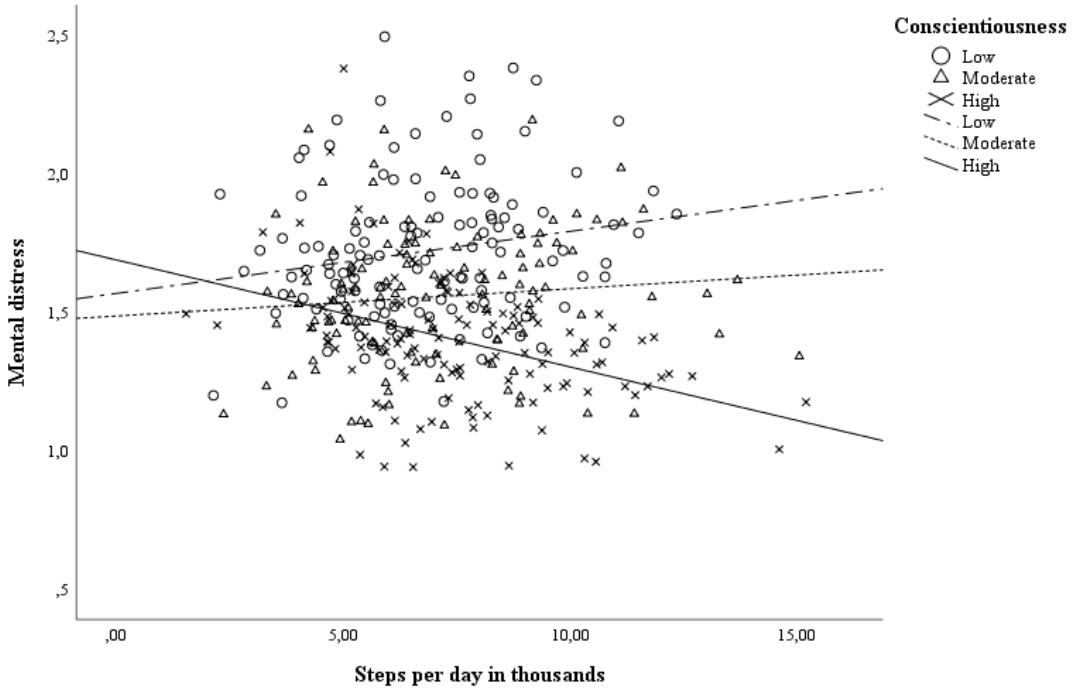

Figure 2. The relationship between Steps per day, mental distress and low, moderate and high Conscientiousness.

When using the Bonferroni correction—in which the alpha level is divided by number of analyses, in this case being *p*-level = 0.05/10 = .005—to adjust the significance level to the number of regression analyses conducted, the only significant relationship remaining was the negative interaction between Conscientiousness and steps.

Table 3

Regression analysis of main and interaction effects of Neuroticism and physical activity (PA) on mental distress

	Model 1[a]			Model 2[b]			Model 3[c]			Model 4[d]			Model 5[e]		
	B [CI][f]	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*
Steps	-.001	.893	.010	.021	.160	.015	.020	.187	.015	.036	.014*	.014	.030	.039*	.015
	[-.021,.018]			[-.008,.050]			[-.010,.049]			[.007,.064]			[.001,.059]		
Neuroticism	.391	.000*	.029	.568	.000*	.093	.548	.000*	.093	.524	.000*	.089	.517	.000*	.088
	[.334,.447]			[.385,.750]			[.364,.732]			[.349,.698]			[.344,.691]		
Interaction				-.024	.046*	.012	-.024	.049*	.012	-.027	.018*	.012	-.027	.020*	.011
				[-.048,.000]			[-.048,.000]			[-.050,-.005]			[-.049,-.004]		
Adjusted R^2	.336			.341			.349			.417			.425		
MVPA	.000	.685	.001	.001	.541	.002	.001	.494	.002	.003	.100	.002	.002	.210	.002
	[-.003,.002]			[-.003,.005]			[-.002,.005]			[-.001,.006]			[-.001,.006]		
Neuroticism	.390	.000*	.029	.450	.000*	.060	.433	.000*	.060	.406	.000*	.058	.401	.000*	.057
	[.334,.447]			[.332,.568]			[.314,.552]			[.292,.519]			[.288,.513]		
Interaction				-.002	.255	.001	-.002	.258	.001	-.002	.098	.001	-.002	.111	.001
				[-.004,.001]			[-.004,.001]			[-.005,.000]			[-.005,.000]		
Adjusted R^2	.336			.337			.345			.411			.420		

Note. N=366. [a]=Physical activity and Neuroticism. [b]=Variables from model 1 and interaction. [c]= Variables from model 2 and demographics (sex, age and season at screening). [d]= Variables from model 3 and lifestyle (BMI, alcohol use, smoking, social network and subjective perception of health). [e]= Variables from model 4 and self-reported PA and mean screen time per day. [f]=Confidence interval. [g]=Moderate to vigorous physical activity. *: p≤.05.

Table 4
Regression analysis of main and interaction effects of Conscientiousness and physical activity (PA) on mental distress

	Model 1[a]			Model 2[b]			Model 3[c]			Model 4[d]			Model 5[e]		
	B [CI][f]	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*
Steps	-.004	.725	.012	.029	.140	.020	.017	.368	.019	.030	.098	.018	.021	.265	.019
	[-.028, .019]			[-.010, .068]			[-.020, .055]			[-.006, .067]			[-.016, .058]		
Conscient-	-.159	.000*	.033	.062	.574	.110	-.024	.826	.107	.056	.583	.103	.032	.752	.102
iousness	[-.224, .094]			[-.155, .279]			[-.234, .187]			[-.145, .248]			[-.169, .234]		
Interaction				-.031	.036	.015	-.021	.138	.014	-.022	.109	.014	-.020	.147	.014
				[-.060, .002]			[-.049 .007]			[-.049, .005]			[-.046, .007]		
Adjusted R^2	.056			.065			.136			.234			.246		
MVPA	-.001	.292	.001	.002	.466	.002	.002	.421	.002	.002	.270	.002	.001	.525	.002
	[-.004, .001]			[-.003, .006]			[-.003, .006]			[-.002, .007]			[-.003, .006]		
Conscient-	-.159	.000*	.033	-.050	.487	.072	-.089	.206	.070	-.026	.701	.067	-.041	.539	.067
iousness	[-.224, .094]			[-.193, .092]			[-.227, .049]			[-.159, 107]			[-.173, .091]		
Interaction				-.003	.092	.002	-.002	.161	.002	-.002	.217	.002	-.002	.249	.002
				[-.007, .001]			[-.006, .001]			[-.005, .001]			[-.005, .001]		
Adjusted R^2	.058			.063			.135			.231			.245		

Note. N=366. [a]=Physical activity and Conscientiousness. [b]=Variables from model 1 and interaction. [c]= Variables from model 2 and demographics (sex, age and season at screening). [d]= Variables from model 3 and lifestyle (BMI, alcohol use, smoking, social network and subjective perception of health). [e]= Variables from model 4 and self-reported PA and mean screen time per day. [f]=Confidence interval. [g]=Moderate to vigorous physical activity. *: p≤.05.

Table 5

Regression analysis of main and interaction effects of Extraversion and physical activity (PA) on mental distress

	Model 1[a]			Model 2[b]			Model 3[c]			Model 4[d]			Model 5[e]		
	B [CI][f]	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*
Steps	-.006	.604	.012	-.023	.241	.020	-.025	.207	.019	-.010	.595	.018	-.016	.409	.019
	[-.030,.017]			[-.063,.016]			[-.063,.014]			[-.046,.026]			[-.053,.021]		
Extraversion	-.141	.000*	.035	-.263	.027*	.119	-.242	.037*	.116	-.119	.283	.111	-.129	.242	.110
	[-.210,-.072]			[-.497,-.030]			[-.470,-.015]			[-.337,.099]			[-.346,.088]		
Interaction				.017	.281	.016	-.016	.311	.016	.015	.307	.015	.015	.321	.015
				[-.014,.049]			[-.015,.047]			[-.014,.044]			[-.014,.043]		
Adjusted R^2	.039			.039			.096			.210			.220		
MVPA[g]	-.002	.200	.001	-.004	.069	.002	-.004	.096	.002	-.003	.204	.002	-.003	.126	.002
	[-.005,.001]			[-.008,.000]			[-.008,.001]			[-.007,.001]			[-.007,.001]		
Extraversion	-.143	.000*	.035	-.231	.002*	.076	-.229	.002*	.074	-.121	.091	.072	-.130	.069	.071
	[-.212,-.074]			[-.380,-.082]			[-.375,-.083]			[-.262,.020]			[-.271,.010]		
Interaction				.002	.193	.002	.003	.147	.002	.003	.071	.002	.003	.089	.002
				[-.001,.006]			[-.001,.006]			[.000,.007]			[.000,.006]		
Adjusted R^2	.043			.044			.099			.214			.225		

Note. N=366. [a]=Physical activity and Extraversion. [b]=Variables from model 1 and interaction. [c]= Variables from model 2 and demographics (sex, age and season at screening). [d]= Variables from model 3 and lifestyle (BMI, alcohol use, smoking, social network and subjective perception of health). [e]= Variables from model 4 and self-reported PA and mean screen time per day. [f]=Confidence interval. [g]=Moderate to vigorous physical activity. *: $p \leq .05$.

Table 6

Regression analysis of main and interaction effects of Openness and physical activity (PA) on mental distress

	Model 1[a]			Model 2[b]			Model 3[c]			Model 4[d]			Model 5[e]		
	B [CI][f]	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*
Steps	-.011	.336	.012	.003	.891	.020	.000	.987	.019	.022	.217	.018	.015	.407	.018
	[-.035,.013]			[-.037,.042]			[-.039,.038]			[-.013,.058]			[-.021,.051]		
Openness	.020	.564	.034	.110	.313	.109	.135	.203	.106	.178	.069	.098	.174	.073	.097
	[-.048,.087]			[-.105,.326]			[-.073,.344]			[-.014,.370]			[-.017,.365]		
Interaction				-.013	.384	.015	-.013	.376	.014	-.017	.184	.013	-.017	.200	.013
				[-.042,.016]			[-.041,.015]			[-.043,.008]			[-.042,.009]		
Adjusted R^2	-.002			-.003			.065			.218			.228		
MVPA[g]	-.002	.221	.001	.000	.858	.002	.000	.927	.002	.001	.516	.002	.001	.739	.002
	[-.005,.001]			[-.005,.004]			[-.005,.004]			[-.003,.005]			[-.003,.005]		
Openness	.020	.552	.034	.067	.333	.069	.078	.242	.067	.097	.113	.061	.101	.098	.061
	[-.047,.088]			[-.069,.202]			[-.053,.210]			[-.023,.218]			[-.019,.220]		
Interaction				-.001	.437	.002	-.001	.564	.002	-.001	.427	.001	-.001	.397	.001
				[-.005,.002]			[-.004,.002]			[-.004,.002]			[-.004,.002]		
Adjusted R^2	-.001			-.002			.062			.215			.226		

Note. N=366. [a]=Physical activity and Openness. [b]=Variables from model 1 and interaction. [c]= Variables from model 2 and demographics (sex, age and season at screening). [d]= Variables from model 3 and lifestyle (BMI, alcohol use, smoking, social network and subjective perception of health). [e]= Variables from model 4 and self-reported PA and mean screen time per day. [f]=Confidence interval. [g]=Moderate to vigorous physical activity.

Table 7

Regression analysis of main and interaction effects of Agreeableness and physical activity (PA) on mental distress

	Model 1[a]			Model 2[b]			Model 3[c]			Model 4[d]			Model 5[e]		
	B [CI][f]	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*	*B [CI]*	*p.*	*SE*
Steps	-.009	.437	.012	.012	.567	.020	.001	.953	.020	.015	.408	.019	.010	.586	.019
	[-.033, .014]			[-.029, .052]			[-.038, 040]			[-.021, .052]			[-.027, .047]		
Agreeable-	-.101	.005*	.036	.038	.741	.114	-.044	.695	.111	.050	.632	.105	.058	.574	.104
ness	[-.171,-.030]			[-.186, 262]			[-.262, .175]			[-.155, .256]			[-.146, .263]		
Interaction				-.020	.020*	.015	-.012	.438	.015	-.010	.472	.014	-.011	.428	.014
				[-.050, .011]			[-.041, .018]			[-.037, .017]			[-.038, 016]		
Adjusted R^2	.018			.020			.092			.209			.219		
MVPA	-.002	.205	.001	.001	.685	.002	001	.638	.002	.002	.421	.002	.001	.571	.002
	[-.005, .001]			[-.004, .005]			[-.003, .005]			[-.002, .006]			[-.003, .005]		
Agreeable-	-.103	.004*	.036	-.006	.938	.072	-.050	.481	.071	.033	.269	.067	.042	.553	.067
ness	[-.173, .033]			[-.148, .137]			[-.189, .089]			[-.100, .165]			[-.090, .173]		
Interaction				-.003	.126	.002	-.002	.213	.002	-.002	.352	.002	-.002	.281	.002
				[-.006, .001]			[-.006, .001]			[-.005, .002]			[-.005, .001]		
Adjusted R^2	.021			.024			.094			.209			.220		

Note. N=366. [a]=Physical activity and Agreeableness. [b]=Variables from model 1 and interaction. [c]= Variables from model 2 and demographics (sex, age and season at screening). [d]= Variables from model 3 and lifestyle (BMI, alcohol use, smoking, social network and subjective perception of health). [e]= Variables from model 4 and self-reported PA and mean screen time per day. [f]=Confidence interval. [g]=Moderate to vigorous physical activity. *: p≤.05.

Discussion

The aims of this article were to investigate the main effects of physical activity and of personality on mental distress, and to examine whether personality has a moderating effect on the relationship between physical activity and mental distress in adolescents. Physical activity was operationalized as objectively measured minutes of moderate to vigorous physical activity per day (MVPA) and steps per day. Personality was operationalized as BFI scores, and mental distress was operationalized as symptoms of depression and anxiety as measured by the HSCL-10.

Results of the current study showed that steps was related to symptoms of anxiety and depression in adolescents with low levels of Neuroticism and high levels of Conscientiousness. No significant simple effects of any of the personality traits were found.

MVPA did not significantly predict mental distress in our sample, in neither main or interaction effects. Previous research has shown mixed results on this matter: Our finding is in contrast to those of Norris et al. (1992), who found anxiety levels to decrease in response to both moderate and vigorous activity levels, with larger effects for vigorous activity. It does, however, fit with the results of Helgadottir et al. (2015), who found no significant relationship between mental distress and MVPA.

A significant main effect of steps on mental distress was found in models 4 and 5 of the analysis on Neuroticism, when covariates such as lifestyle, self reported health, self reported physical activity during leisure time, and screen time were adjusted for. Because significance occurs upon control for these variables, at least some of them contribute to the association between physical activity and mental distress. The significant interaction between steps and Neuroticism in model 2 indicates that this association is dependent upon the trait Neuroticism. No similar associations were found in analyses on other personality traits.

Extraversion had a significant negative main effect on mental distress in models 1 to 3 in both steps and MVPA analyses, indicating that participants with lower scores on Extraversion experienced a larger degree of mental distress. The relation became nonsignificant upon inclusion of alcohol use, smoking, perception of one's own health, BMI and satisfaction with social network, as adjusted for in model 4. Knowing which variable(s) included in model 4 caused the effect of Extraversion to be reduced is not possible, due to the inclusion of several covariates in the same model. However, one may speculate if the inclusion of perception of health could have contributed to this change in significance: Perceiving one's own health as worse than it is in reality is known to cause psychological distress, and health-related anxiety has been found to be present in most anxiety disorders (Abramowitz, Olatunji & Deacon, 2007). Extraversion and Conscientiousness have been found to have a significant positive relation, and Neuroticism has been shown to have a significant inverse relation to subjective well-being (Costa & McCrae, 1980; Grant, Fox & Anglim, 2009).

Although our sample showed only small tendencies for presence of mental distress, it is reasonable to assume that the results would be sensitive to those participants who did have somewhat more anxiety. A connection between perception of illness and anxiety and depression has also been found (by e.g. Morgan, Villiers-Tuthill, Barker & McGee, 2014 and Hagger & Orbell, 2003).

One could also speculate if the covariate satisfaction with social network is of importance to the experience of mental distress, and could have contributed to the change in significance of the relation. A common consequence of dissatisfaction with social network is loneliness, which has also been found to be strongly related to depression in adolescents (Spithoven et al., 2017). Studies have also shown that Introversion to be related to loneliness (Saklofske, Yackulic & Kelly, 1986; Levin & Stokes, 1986), perhaps making participants

high in Introversion more prone to experiencing mental distress, independently of physical activity.

It is possible that there is no actual main effect of Extraversion on mental distress, and that covariates such as these in reality determine the degree of mental distress experienced by the participant. However, as perception of health and satisfaction with one's social network are central aspects of the experience of mental distress, controlling for variation caused by these variables may in fact be an overadjustment of factors which should remain included.

Analyses further revealed significant positive main effects of Neuroticism on mental distress in all models, meaning that individuals higher in Neuroticism also experienced more mental distress. This finding was in accordance with our expectations, as the majority of studies on the relation between personality and mental distress confirm this link (e.g. Kotov et al., 2010; Malouff et al., 2005). Our study thus provides further support that at least certain aspects of personality is of importance to the development of mental distress.

Personality can be of importance to how physical activity affects mental distress: Even though numerous studies find physical activity to reduce mental distress, it can actually have negative impact on mental health for some individuals. For instance, increased mental distress can occur in cases of exercise dependence, which is the phenomenon of using physical activity as a way to escape or distract oneself from problems, whereas a lack of physical activity increases mental distress (Hausenblas & Downs, 2002). Hausenblas and Giacobbi (2004) found that exercise dependence was positively correlated with Neuroticism and Extraversion, and negatively correlated with Agreeableness. This shows that different personality traits can have different impact on the effect of physical activity on mental distress, which means that it is important to be cautious about generalizing the effects of physical activity.

Contrary to our expectations, multiple hierarchical regression analyses did not provide support for the hypothesis that the effect of physical activity on symptoms of anxiety and depression in youth is moderated by the personality traits Openness, Extraversion and Agreeableness. As expected, initial regression analyses did reveal significant negative moderating effects of Neuroticism and Conscientiousness on the effect of steps per day on mental distress.

Upon further investigation of the finding that the interaction between Neuroticism and steps may have impact on mental distress, the results showed that the effect of steps was larger for participants with high scores on Neuroticism compared to those with lower scores. An increase in steps was associated with lower mental distress for this group. No similar effect was seen in the group with moderate scores on Neuroticism. A counterintuitive opposite effect was found in the low Neuroticism group, in which an increase in steps was associated with higher mental distress. These simple effects were nonsignificant as the effects of steps was small in all groups, but as the *p*-value of this group was much lower than that of the moderate and the high group, it seems likely that it was the low Neuroticism group that caused the observed significant effect in the main analyses.

A possible explanation may be that whereas people high in Neuroticism may experience increased discomfort in response to inactivity due to negative self-evaluations of not having been active enough, participants with lower scores on this trait may experience less feelings of low self-efficacy as a result of inactivity, and in turn encounter larger mental distress in response to energy expenditure through walking or running as opposed to more comfortable options, such as driving or utilizing public transport. However, the relation in the borderline significant low-neuroticism group was small, and as shown in figure 1, it is likely that outliers contributed heavily to this result.

The negative interaction effect between Conscientiousness and steps on mental distress was borderline significant in the high Conscientiousness group in the simple effects analyses, indicating that increasing activity could have a small protective effect on mental distress for this group. This relation was the only one which remained significant after using the Bonferroni correction, which means that we can reject the null-hypothesis with somewhat larger certainty for the Conscientiousness and steps interaction. However, the interaction became nonsignificant when adjusting for gender, age and the time of year for testing of participants. Because participants were roughly the same age and the majority were tested during winter season, we can assume that gender caused this effect. This means that some of the variation in mental distress that in initial models was explained by Conscientiousness in reality was explained by gender.

Personality did not significantly moderate the effect of MVPA on mental distress in this study. Similar results were found by Toseeb et al. (2014), who applied objective measures of MVPA to longitudinally examine the relationship between physical activity and depression.

As mentioned in the introduction, results of research on the relation between physical activity and mental distress in adolescent samples are inconsistent. Findings such as those of Birkeland and colleagues (2009, p. 32), that showed no prospective relation between physical activity and symptoms of depression in an adolescent sample, support the idea that there are variables other than physical activity that are more important for mental distress outcomes. The main assumption in our study was that one such factor would be personality. This was also hypothesized by De Moor et al. (2006, p. 273), who argue that this relationship is likely, due to the fact that particularly the traits Neuroticism and Extraversion are related to anxiety and depression, and because personality has an impact on lifestyle habits. No significant moderating effects were found in the relationships between Extraversion or Agreeableness

and the physical activity variables in our study, meaning that according to our findings, the known associations between physical activity and mental distress cannot be explained by an individual's levels of Extraversion or Agreeableness. This is contradictory to the the findings of Brunes and Augestad (2012), DeMoor et al. (2006) and Wilson and Dishman (2015).

Another possibility is that the results may reflect over adjustment, as our models (particularly models 4 and 5) included large amounts of covariates that rather than confounding the effect of personality, may actually have mediated the effect. For instance, personality may have influenced the tendency to perceive own health as good or bad, or the perception of own social network, which in turn could influence mental distress. Such a situation warrants a different interpretation of the situation. As longitudinal data is needed in order to investigate mediating effects, questions such as these could not be investigated in the current study.

As the study was conducted on a non-clinical sample with few symptoms of mental distress (mean HSCL-10 score was below clinical cut-off, and 76,2% of the participants did not have symptoms compatible with clinical disorder), results are not representative for the clinical adolescent population. Scores on HSCL-10 in our sample might have been too low for them to benefit from physical activity as much as they would if they experienced more mental distress. It is possible that mental distress and personality traits could have different relations in purely clinical adolescent populations. Had our sample included participants with higher mental distress, personality might have shown more moderating on the relationship between physical activity and mental distress.

Both subjective and objective indicators of health suggests that our sample was generally healthy: Smoking was relatively uncommon for both sexes, alcohol use was moderate, and most participants considered their health to be good. All BMI means were within the normal range (WHO, 2000, p. 9). They generally met the recommendations of 30

minutes of activity a day, but did not meet the informal recommendation of 10,000 steps a day (Choi, Pak & Choi, 2007), and spent approximately somewhere between 2–3 and 4–6 hours on screen time activities, indicating that the sample also was relatively sedentary. Their tendencies for both active and sedentary behaviour might have affected their experience of mental distress in the first place.

Participants excluded from our study because they did not wear the accelerometer for the required time, may have failed to do so because of mental distress, in which case the data can be less representative than presumed. This can be part of the explanation as to why we found no significant results on depressive symptoms. Still, the fact that female participants reported higher scores on HSCL-10, could indicate that it is a representative group, as this seems to be the case in the Norwegian population (Reneflot et al., 2018).

The nonsignificant results on depression in the current study are interesting, as physical activity is shown to have significant effects on depression in multiple studies (e.g. DeMoor et al., 2006; Kremer et al., 2014; Kubik & Dishman). The findings of these studies are all based on self report measures of physical activity. Studies in which objective measures of physical activity have been applied, generally do not find significant relations with mental distress (Van Dijk et al., 2016; Toseeb et al., 2014; Hume et al., 2011). Our findings thus fit with those of other studies in which objective measures have been applied, further emphasizing the recognition that measurement methods can have impact on findings.

Because personality was not measured at baseline (FF1), we could not conduct a longitudinal study to investigate the effect of physical activity on mental distress over time. However, other researchers who have used objective measures of physical activity in longitudinal studies (Van Dijk et al., 2016; Toseeb et al., 2014) did not find significant effects over time, which may indicate that there are no longitudinal effects when objective measures are applied.

Even though a relatively large sample was used in the current study, investigations on a larger number of participants is necessary in order to draw conclusions. The small sizes of our findings and lack of significance in most associations, indicates that the potential association between physical activity and mental health in youth, may be better explained by factors other than personality. As pointed out by Wilson and Dishman (2015, p. 240), however, the fact that physical activity and personality are dynamic constructs, means that personality traits might vary in how they contribute to physical activity. Personality changes throughout life can subsequently be assumed to make both inhibition effects on physical activity, and protection effects of physical activity on mental health, work in different ways for different people. This further means that similar research on other populations may result in different findings.

As described in the introduction, research shows that adolescence is a period of life in which prominent changes in the patterns of personality occur. Although it continues to develop throughout life, personality appears to be increasingly stable over the years after adolescence (Soto et al., 2011; Donellan & Lucas, 2008; Roberts & Mroczek, 2008). Personality development in adolescence could explain why we see mixed results on the effect of physical activity on mental distress in adolescent samples. If, for instance, the sample of the current study was particularly high in Neuroticism at the time of measurement, in accordance with findings that there is an increase in this trait during the adolescent years (Soto et al., 2011), this might have contributed to the somewhat counterintuitive result that steps had an inverse effect on mental distress for the low Neuroticism group. The results might also reflect that the increase of Conscientiousness from adolescence into adulthood tends to be larger for women, as the effect of Conscientiousness disappeared when gender was adjusted for.

No norms were available for the version of the Norwegian BFI used in this study, which limited our ability to compare the personality scores of our sample to those of the general adolescent population. Because this version of the BFI does not have the same number of Likert-scale response options as other versions, comparison of our sample to the norm groups of other BFI versions was also not appropriate. As the sample of the current study consisted only of the participants who had no missing values on the relevant variables and covariates, it seems likely that these participants might have been particularly high in Conscientiousness. If this was the case, it could mean that they were also prone to follow general health recommendations, meaning that the sample might be more physically active than the general population. As the Conscientiousness trait also reflects ability to plan, as well as self-discipline to carry out the plans, the likelihood of conscientious adolescents engaging in physical activity can be assumed to be even higher (Rohodes & Smith, 2006). In a meta-analysis, Bogg and Roberts (2004) found that Conscientiousness correlated positively with health-promoting behavior.

It is also possible that our sample was more extraverted than expected from the general population. As Extraversion is associated with sociability, activity, and sensation seeking, all of which will often involve activities such as walking in contrast to sedentary behavior, one could speculate if participants with higher scores on Extraversion might be more prone to light physical activity than participants with lower scores on Extraversion (Rhodes & Smith, 2006). If measured again on a later event, personality scores, and thus results, might be different.

It is possible that our participants' self reports of personality traits may be biased: Some may have reported inaccurately due to social desirability, the desire to respond in a way that will put oneself in a better light. One could also speculate if the tendency to report falsely in response to the wish to appear better might also be affected by personality. Austin, Deary

and Egan (2006) for example, found that participants higher in Conscientiousness and Extraversion more often responded on the extremes of the scales.

An overview of additional factors of importance to the relation between physical activity and mental distress, including to what degree and under which circumstances they have an impact, is needed in order to fully explain existing findings on the relationship. One relevant factor which was not included in our analyses, is socioeconomic status (SES). It is known that SES is strongly associated with lifestyle and mental distress (i.e. Bøe, Øverland, Lundervold & Hysing, 2012; Barrett & Turner, 2005; Smith, 1999). Bøe et al. (2012) investigated the effects of SES on mental health in 5,781 Norwegian adolescents aged 11 to 13, and found that SES strongly predicted symptoms of depression and other disorders (Bøe et al, 2012, p. 1560). Furthermore, Smith (1999, p. 148–149) writes that income inequality may also affect health as it affects exposure to stressful life events over time. The researcher further states that risk behaviors such as smoking, sedentary behavior and unhealthy diets have higher prevalence among people with low SES, and that these individuals may also have less resources for participation in health promoting behaviors.

Other factors which are likely to be of importance include self-esteem (Biddle & Asare, 2011; Calfas & Taylor 1994) and social desirability. These factors were also not measured in our study, and should be taken into account in future research in order to enable greater understanding of the mechanisms behind the relationship between physical activity and mental distress. The majority of our sample was tested during the winter, and this could also have had an impact on the results.

Cardiorespiratory fitness (CRF) is another factor that might be of importance for our research question, but was not included in this study. Yeatts et al. (2017) found that CRF had a moderating effect on the relationship between Neuroticism and depression: Individuals who had high scores on both Neuroticism and measures of CRF, had fewer depressive symptoms

compared to those with lower scores. CRF is likely to result from intensive physical activity rather than a high amount of steps per day, which was the type of physical activity found to have a potential impact on mental health in our study. This difference between CRF and steps per day, can be what caused the differences in results between the current study and that of Yeatts and colleagues.

Self reports in the current study indicated that mean levels of leisure time physical activity were somewhere between low and moderate; this was in accordance with accelerometer measures of steps per day, which also indicated that the sample was relatively active. Our results did not reveal a significant relation between self reported leisure time physical activity and mental distress, which is contradictory to results found by Moksnes et al. (2010), Bélair et al. (2018) and White et al. (2017), who all found leisure time physical activity to be negatively correlated with mental distress. That neither of these used objective measures on physical activity, might explain the difference.

White et al. (2017) found leisure time physical activity (as opposed to physical activity in association to work, education, commuting, and household chores) to be the most effective for prevention of mental illness in adults and adolescents. A possible explanation for this finding (if self reports were accurate), could be that intrinsic motivation and other positive aspects of leisure time activities, such as effects on social network and identification to certain reference groups, might make physical activity more enjoyable under such circumstances, thus preventing or reducing mental distress.

Mean amount of MVPA for our sample was approximately 35 minutes per day. However, there were large variations within the sample, perhaps reflecting differences between the adolescents who participated in team sports or other forms of moderate to high intensity spare time activities, and those who did not. Most met the recommendation for adults, of 30 minutes of physical activity per day, but few met the recommendation for

children, of 60 minutes per day. The current sample engaged in more MVPA compared to the average Norwegian adult, according to the results of a national survey, in which MVPA was also objectively measured (Hansen et al., 2015).

The context of physical activity can be of importance. The current study did not examine the frequencies of active participants who engaged in team sports and in individual physical activity, respectively. Such information could have provided important insight about our results, as team sports have been found to have a larger positive effect on anxiety compared to individual physical activity for boys and girls (McMahon et al., 2016, p. 7). If the potential protective effect lies in contextual aspects (such as the social aspect of most team sports), this can be an explanation for the mixed results on the effect of physical activity. When context is not controlled for, estimates include both social contexts and physical activity done alone, and these might have very different effects.

Because of the considerable amount of research linking physical activity inversely to mental distress, as well as evidence for the relations between personality and mental distress, we anticipated that there would be more significant findings of our regression analyses. Nonetheless, as our main findings were based on objective measures of physical activity, whereas the majority of existing research is based mainly on self report, the findings of the current study can be regarded as trustworthy. To our knowledge, the only other cross-sectional study using objective measures on physical activity, was conducted by Hamer and Stamatakis (2010) on an adult population of 921 participants (M_{age} = 44.6). The researchers found no associations between MVPA or fitness and psychological well-being (measured by the GHQ).

Strengths and limitations

There were several limitations in this study. As this was a cross-sectional study, the lack of follow-up measures hindered insight in the relationship between physical activity, mental distress and personality over time, and so we could not draw any causal conclusions. No clinical diagnoses were used (but an instrument with good psychometric qualities was). We also lacked measures on SES. Screen time was measured by self report. No norms were available for the version of BFI used in the Fit Futures study. This means that the scores of our sample could not be compared to any form of control group, which limited our possibility to draw conclusions about the personality traits. However, due to the high response rate and representativeness of our sample, there is reason to believe that there would be no significant differences between or sample and the general population. There is a possibility of our results being random. Participant drop out is one reason for this. Our analyses were only based on data from the 366 participants who had no missing values: It is plausible that these particular participants had larger commitment to the task (wearing the accelerometer for the time required) than others, which may indicate that these individuals would have somewhat heightened scores on the trait Conscientiousness and/or Agreeableness. The sample also might have been selective if they experienced less mental distress and did more physical activity than a more representative sample would have.

Strengths of the study include objective measures on physical activity, a representative and relatively large sample as well as high response rate.

Conclusions

We did not find physical activity to be related to mental distress. Personality seemed to have some impact on the relation between physical activity and mental distress in our adolescent sample, but it was only one of many factors which may moderate the relationship.

A negative interaction between steps per day and low scores on Neuroticism, and a negative interaction between steps and high scores on Conscientiousness were found, but these results were highly uncertain. We can not rule out other biological, environmental or social factors that impact physical activity. Because personality is fluctuating, longitudinal objective measures controlling for SES are needed.

Implication for future studies. The type and context of physical activity (social vs. individual) should be examined, and objective measures on physical activity should be further used. Conduction of longitudinal studies can contribute to greater knowledge of the directions of relations between physical activity, mental distress and personality in adolescents.

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