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In the review of Gerber and Pühse, 16 studies supported the validity of a leisure time physical activity and exercise-based stress-buffer hypothesis, where six studies were based on adolescent samples (one Norwegian study included) [19]. In contrast, 15 investigations (five based on adolescent samples) did not support the stress-buffering hypothesis. The variation in results was explained by the diversity of sample characteristics, study designs and measurements and further research is needed to explain these different findings. A recent study by Sund, Larsson and Wichstrøm found support for a stress protective role of vigorous exercise in relation to depression in adolescents, whereas a recent Norwegian study investigating the stress protective role of leisure time physical activity in relation to depressive symptoms in adolescents did not find support for this moderation effect [17,20].

Gerber, Holsboer-Trachslar, Pühse and Brand and Rethon et al. suggest several explanations for how physical activity alleviates the negative effects of stress [18,21]. The first is the distraction hypothesis, where physical activity provides a "time out" that enhances mood and reduces arousal during periods of high stress. Second, physical activity results in higher levels of fitness and – as an indirect consequence – a more efficient physiological and psychological stress regulation or enhanced recovery processes. The physiological stress regulation includes reduced physiological reaction of the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal axis to stressors in general (HPA) [22]. A reduction in physiological stress reaction is reflected by a lower stress reactivity and faster recovery. Physical activity may also promote psychological stress regulation by strengthening personal resources (i.e. self-esteem, autonomy, optimism, coping) and social resources (i.e. social support), which in turn can have the potential to have impact on the stress-health relationship [21].

As described, stress, physical activity and psychological health are highly related, and therefore likely to show changes during adolescence based on the impact of developmental shifts, challenges and transitions occurring in this period [3-6,17,18]. Physical activity might have as a possibility to reduce or neutralize the negative outcomes associated with different stressors [19]. However, the role of physical activity in relation to mental health outcomes as well as the stress-buffering effects of physical activity has received significantly less attention in children and adolescents than in adult populations [19,22,23]. In this context, developing a more thorough understanding of the association between these constructs requires distinguishing among domains of stress, as physical activity might have a buffering effect only for certain subtypes of stressors [6,17,24]. The relations between physical activity, stress and depressive symptoms may differ between girls and boys, and separate analyses for gender may give a more comprehensive understanding of these relations. Understanding the role of stress is important for the identification of those adolescents most in need of early identification. Further, clarification of the role of physical activity in relation to stress and mental health can be used to form interventions to strengthen a healthy development in general, as well as to support the young with potential risk.

Based on the empirical findings presented above, the aims of the study are:

To investigate gender and age differences on leisure-time vigorous physical activity (LVPA). It is expected that boys will score higher on LVPA than girls in all age groups.

To investigate the association between stress domains and the outcome of depressive symptoms separately for girls and

boys. It is expected that stress is positively related to depressive symptoms.

To investigate the association between LVPA and depressive symptoms separately for girls and boys. It is expected that a negative association is found.

To investigate the potentially protective role of LVPA on the relation between stress domains and the outcome of depressive symptoms. Based on previous empirical findings where about half of the studies supported a stress-buffering hypothesis of physical activity (including two Norwegian studies), it is expected that a moderation effect will be found [15].

Methods

Participants

The cross-sectional sample in the present study involves the participation of six public elementary and secondary schools in two counties in Mid-Norway. A total of 1229 questionnaires were distributed (593 in elementary schools and 636 in secondary schools).

The number of completed questionnaires returned was 1209, giving an overall response rate of 98.4 %; 617 (51.0%) were girls and 586 (48.5%) were boys (gender was not identified for six of the participants). The age range of the sample was 13 – 18 years. Of the responding subjects, 26 were out of the age range, leaving 1183 cases for the analyses. The data was collected during September and October of 2008.

Procedure

In reference to the Norwegian medical ethical guidelines, the present study and research project was approved by the Regional Committees for Medical Research Ethics and the Norwegian Social Science Data Services. The headmaster from each of the schools approved the content of the questionnaire prior to agreeing to participate in the survey. The adolescents and their parents received an information letter that briefly explained the purpose of the study. Passive consent from the participants was found to be sufficient because all data were anonymous and any adolescent who did not provide an active negative response was eligible to be part in the study. Questionnaire administration was completed in one section, in whole class groups, during one regular school class of 45 minutes. The small number who did not respond (n=20) were either not at school that day or declined to answer the questionnaire.

Measures

Adolescent stress was assessed using the 30-item version of the Adolescent Stress Questionnaire (ASQ-N). This is originally a 58-item questionnaire concerning common adolescent stressors assessed during the last year and rated on a 5-point Likert scale: 1 (*not at all stressful or is irrelevant to me*); 2 (*a little stressful*); 3 (*moderately stressful*); 4 (*quite stressful*); and 5 (*very stressful*). The ASQ has been continuously developed and validated since the mid-1990s and the instrument has been successfully tested for use in a Norwegian adolescent sample [1,2]. Further validations of the instrument have reduced the scale to 30 items, with support for high internal consistency and construct validity [25]. The scale consists of seven dimensions reflecting the following stressors: teacher/adult interaction (e.g., lack of respect from teachers, not being listened to by teachers); peer pressure (e.g. peers hassling you about the way you look, pressure to fit in with peers); home life (e.g. abiding by petty rules at home, disagreements between

your parents); romantic relationships (e.g. not enough time for your boyfriend/girlfriend, getting along with your boyfriend/girlfriend); school attendance (e.g. abiding by petty rules at school, compulsory school attendance); school/leisure conflict (e.g. not enough time for leisure activities, not enough time for activities outside school hours); and school performance (e.g. difficulty with some subjects, teachers expecting too much from you). Cronbach's alpha for the stress dimensions in the present study is reported in Table 2.

Depressive symptoms: A non-clinical depression scale was used to assess state depression. The scale constructed by Byrne et al., consists of a 15-item questionnaire measuring the respondent's level of commonly experienced but essentially non-clinical depressive attributes during

predictor variables of age, stress dimensions and leisure time physical activity and the outcome of depressive symptoms separately for boys and girls. The moderation effect was tested with two-way interaction effects between each stress dimension and leisure time physical activity. The variables in the interaction terms were centred before they were entered in the regression analysis. There were no indications of multicollinearity, with VIF values < 10 and tolerance ranging between .42 - .96. *P*-values < .05 were considered statistically significant.

Results

Descriptive statistics and correlations analysis

Descriptive statistics with presentation of mean scores and standard deviation for gender on all variables are presented in Table 1. Girls scored significantly higher than boys on all variables except for on stress related to teacher/adult interaction and school attendance, where no significant gender differences were found. Cronbach's alphas and results of the correlation analyses of the scales are presented in Table 2. All stress dimensions were positively and significantly inter-correlated, and significant, positive correlations were found between all of the stress dimensions and depressive symptoms for both genders. When looking at the correlations between LVPA and the other variables for girls, LVPA showed significant, negative and weak correlations with stress related to "home life" and "school attendance", whereas a significant negative and weak correlation was found between LVPA and depressive symptoms. The correlation between LVPA and age was not significant for girls. For boys, LVPA was not significantly correlated with any of the stress dimensions or with depressive symptoms; however, a weak, positive and significant correlation was found between LVPA and age.

Gender and age differences on leisure time vigorous physical activity

The results of the two-way between-groups ANOVA showed a significant main effect of gender on leisure time physical activity, $F(3, 1142) = 16.71, p < .001, \eta^2 = .01$, where boys ($M = 3.52, SD = 1.19$) had higher mean scores than girls ($M = 3.24, SD = 1.08$). There was also a significant main effect of age on leisure time physical activity $F(2, 1142) = 5.96, p < .01, \eta^2 = .01$. The post-hoc test showed that those 13-14 years of age ($M = 3.23, SD = 1.15$) scored significantly higher on frequency of leisure time physical activity than those 16-17 years of age ($M = 3.50, SD = 1.12$) ($p < .01$). Finally, the interaction effect of gender by age on physical activity was significant $F(2, 1142) = 5.35, p < .01, \eta^2 = .01$, showing that boys' mean scores on physical activity increased with age, whereas girls' mean scores remained more constant across the three age groups. The effect sizes showed that the main effects and the interaction effects were small (Table 1 and Table 2).

Associations between stress, leisure time vigorous physical activity and depressive symptoms

Results following the multivariate hierarchical regression analysis for variables predicting depressive symptoms are presented separately for boys and girls in Table 3. Age was not a significant predictor of depressive symptoms for boys in any of the steps, and was only significant in the first step for girls, showing a weak positive association with depressive symptoms. The stress dimensions added a significant R^2 increment to the model, where stress of peer pressure, home life, school attendance and school performance were significantly and positively associated with depressive symptoms in all steps of the model for both boys and girls. For girls, stress of home life was additionally

significantly and positively associated with depressive symptoms.

The stress dimensions explained 42% of the variance in depressive symptoms for girls and 29% of the variance in depressive symptoms for boys. LVPA was added in step three, but it was not a significant predictor in association with depressive symptoms for either boys or girls. However, when looking at the interaction effects for boys, a stress protective role was found from high LVPA in relation to stress of peer pressure, teacher/adult interaction and school performance. For girls, a significant stress protective effect of high LVPA was found in relation to stress of home life and peer pressure. However, the interaction effects were of a small magnitude, accounting for only 2.3 % of the variance in depressive symptoms for boys and .08 % of the variance for girls. In sum, the predictors explained 43% of the variance in depressive symptoms for girls and 31% of the variance in depressive symptoms for boys (Table 3).

Discussion

The results of the study gives a comprehensive picture of domain specific stress, LVPA and depressive symptoms in adolescent boys and girls and the role of LVPA as a potential protective factor in this particular relationship.

In line with the first hypothesis in the study, gender and age differences on LVPA were found where boys' scores increased with age, whereas girls' scores remained stable across the age groups; however, boys' mean scores were consistently higher than girls' for all age groups. The results are in line with previous findings showing that boys are more physically active than girls, but contradict previous findings showing that the amount of physical activity seems to decline with age both among boys and girls during adolescence [14,15]. Physical activity is a behavior influenced by complex intrapersonal, social and environmental factors, and there are a number of potential explanations for the observed gender differences found on LVPA. This includes differences in the availability of sporting options, gender role expectations and body image concerns as well as girls' decreased participation in non-organized sport and vigorous physical activity during the adolescent years [15,33]. A study by Rangul showed that dissatisfaction with life, being overweight, and not participating actively in sports were the strongest predictors for decreased physical activity among boys [34]. The strongest determinants for decreased physical activity in girls were risk behaviors like smoking, drinking and low maternal education. In reference to the stable level of physical activity found for girls across age groups in the present study, it is likely to believe that the individual and/or contextual factors that are likely to decrease LVPA may not be relevant for girls' activity level in the present study. Type of activity and different settings in which physical activity takes place was not assessed in the present study and could have contributed with some important information regarding adolescents' choices of activities and potential gender differences in these aspects [35].

The results partly supported the second hypothesis of the present study, showing that adolescents who perceived higher levels of stress in relation to the school context, home life and the peer group also reported significantly higher scores on depressive symptoms. Stress of romantic relationships and school/leisure conflict was not significantly associated with depressive symptoms for either boys or girls. The stress dimensions explained 42% of the variance in depressive symptoms for girls and 29% of the variance for boys. Relations between stressors, especially those in an interpersonal context and symptoms

of peer pressure, teacher/adult interaction, home life and school performance). On the basis of the cross-sectional design used in the present study, the significant interactions might mean that adolescents who engage in physical activity are less affected by stressors or that those who feel unaffected are more likely to maintain high physical activity levels. However, the interaction terms explained only .08% of the variance in depressive symptoms for girls and 2.3% of the variance for boys. From this point of view, it seems inappropriate to overstate the moderating role from LVPA. It is therefore likely that there may be other factors, not assessed in the present study that might interact on the associations found. However, these aspects still remain unexplored, and continued research is needed to reveal such interactions. Findings thus indicate that due to the strong relation found between stress domains and depressive symptoms, stress appears to negatively affect health, irrespective of adolescents' frequency of LVPA.

On the basis of present findings, one implication will be to focus on interventions reducing adolescents' exposure to potential stressors. However, given that little control can be gained over young people's exposure to a variety of stressful situations, a more prominent target will be to increase children's and adolescents' coping abilities in relation to experiences of stress. Although girls' scores on LVPA did not decrease with age, boys scored consistently higher on LVPA than girls across all age groups, supporting the need for gender specific strategies to facilitate physical activity for girls. To improve skills in problem solving, skills in impulsivity control and receiving adequate social support may also increase resilience in the face of stress.

Strengths and limitations

A major strength of the present study is its large sample size and high response rate, however, the study should be considered with some limitations in mind. The cross-sectional nature of this study is an important limitation and precludes causal interpretation of both main and interaction effects. A longitudinal design would have strengthened the study by allowing changes and associations to be assessed and compared over time, and this is contemplated in future research. Further, there is disagreement over whether or not self-report measures allow a valid assessment of exercise participation. LVPA was studied by using one single item, which may have contributed to misclassification and self-report bias because of possible varying levels of comprehension of the question, especially for the younger age groups. The LVPA item also focused solely on vigorous physical activity and the use of scales or composite measures that assess the wider range of physical activity in adolescents, could possibly have led to an increase in reliability. Further, the study could have evaluated the exercise behavior of the sample, by distinguishing between adolescents partaking in organized sports versus those who exercised independently. The measurement of depressive symptoms was conducted using an instrument assessing non-clinical depressive attributes within the last week. This was regarded as an appropriate instrument in reference to that the study focused on the general adolescent population, with no known indications of mental health problems. However, in order to assess clinical symptoms of depression, it is important to use an instrument where symptoms are assessed within a two weeks frame in order to avoid false positives [26]. All data were derived from subjective self-report measures and are therefore subject to potential self-reporting bias. Self-reports require that adolescents are at a level of cognitive development where they are able to reflect and understand concepts of health and illness and are thus able to give reliable evaluations. The study of Haugland and Wold found support for the belief that adolescents between 14 – 16 years of

age are able to give reliable information about their subjective health by use of self-report questionnaires [38,39]. It should be acknowledged, however, that all such data might be more prone to bias due to the possible influence of social desirability factors [40]. The large sample size of the present study can protect against the influences of potential random errors related to self-report [41].

Conclusion

Findings in this study indicated gender and age differences in LVPA, where boys consistently reported higher frequency of LVPA compared to girls in all age groups. Adolescents, who perceived higher levels of stress in relation to the school context, home life and peer group, also reported significantly higher scores on depressive symptoms. LVPA was not significantly associated with depressive symptoms for either boys or girls. However, a stress protective role was found from high LVPA in relation to stress of peer pressure, teacher/adult interaction and school performance for boys. In girls, a significant stress protective role of high LVPA was found in relation to stress of home life and peer pressure. In sum, interpersonal stressors and school related stressors explained most of the variance in depressive symptoms, especially in girls. LVPA had a weak stress moderating role in relation to depressive symptoms. Further elaboration of the results

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