



Longitudinal Changes in AbsoluteVO_{2peak}, Physical Activity Level, Body Mass Index, and Overweightness among Adolescents in Vocational and Non-Vocational Studies

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The purpose of the study was to examine differences in physical activity level, physical fitness, body mass index, and overweight among adolescents in vocational and non-vocational studies, at the age of 14, 16, and 19, using a 5-year longitudinal design. Students in sport studies had the highest absoluteVO_{2peak} and higher physical activity levels, than students in vocational subjects and students with a specialization in general studies. However, there were no significant differences between students in vocational subjects and students with a specialization in general studies according to absoluteVO_{2peak} and physical activity levels. Students in vocational subjects were significantly more overweight/obese at 19 years of age, compared with the other students. Our findings support previous research pointing to overweightness as being more widespread among adolescents in vocational programs than in non-vocational programs. However, differences in the physical activity level and physical fitness do not seem to explain these differences.

Keywords: adolescence, physical activity, physical fitness, overweight, vocational students

INTRODUCTION

Physical activity level, cardiorespiratory fitness, and weight status seem to be fundamental factors associated with adolescents' and adults' health (1–4). However, physical activity level seems to decrease over time among adolescents in general (5–8). Belanger et al. (5) found that the prevalence of participation by adolescents in most activities declined over a 5-year period; it did not increase for any activity. Within 2 years of baseline, most adolescents discontinued participation in most activities in which they had reported participation at baseline. Research has shown that cardiorespiratory fitness (absoluteVO_{2peak}) seems to increase slightly or be stable over time (9). Changes in physical performance between 16 and 18 years of age seem to be very similar in different countries, despite differences in physical activity patterns and absolute level of performance (10).

Overweightness seems to be widespread among adolescents all over the world, and cardiorespiratory fitness is highly correlated to body mass and overweightness (11). The prevalence of childhood overweightness has also increased worldwide during the last few decades (12). A study on high school students in Sweden showed that 23% of the students suffered from overweightness

or obesity (13). Similarly, Arngrimsson et al. (14) found that among 18-year-old Icelandic students, 23% were overweight or obese. Research has also shown that overweightedness and obesity affect both boys and girls. Bovet et al. (15) found that the prevalence of overweightedness or obesity in the Republic of Seychelles was 11.2% in boys and 17.5% in girls, and a study on Norwegian children (4–15 years old), found that 18% of boys and 20% of girls were above the 90th weight-for-height percentile. This issue of overweightedness continues from childhood and into late adolescence and adulthood. In their 2016 article, Spook et al. (16), concluded that overweightedness remains a major issue among secondary vocational education students in the Netherlands.

Although there is a general concern regarding adolescents' and adults' physical activity level, cardiorespiratory fitness and weight status, research indicates that some occupational groups may be more inactive, have lower cardiorespiratory fitness, and have less functional weight status than other occupational groups. Breivik and Rafoss (17) highlighted a major concern regarding differences in health-related behavior in different occupations, such as vocational and non-vocational employment. It may seem as though dividing lines related to education, employment, and type of profession still follow the old dividing lines where white-collar professionals incorporate higher levels of physical activity into their leisure time compared with blue-collar professionals. There are clear differences in employees' physical activity levels in relation to their education. Employees who have taken university subjects such as science, psychology, and humanities have high physical activity levels, whereas employees with various types of vocational and industrial work have lower physical activity levels. Nash (18) pointed out that Bourdieu's theory of habitus, may explain why participation in physical activity is influenced by education level.

Research also indicates differences between vocational and non-vocational adolescent students. For example, a study on high school students in Sweden showed that students in vocational programs reported poorer self-related health than those in non-vocational programs (13). Another study showed that students in vocational programs had lower levels of activity compared with students in non-vocational programs (19), with girls enrolled in vocational subjects being the least active and boys with a specialization in general studies having the highest level of activity. Alricsson et al. (20) found that more students in academic programs participated in sports compared with those in vocational programs. A study by Arngrimsson et al. (14) also showed that vocational students had lower levels of fitness and higher body fat percentages than non-vocational students. In addition, several studies found that overweightedness is more widespread among adolescents in vocational programs than among those in non-vocational programs (13, 21). van der Horst et al. (21) also found that vocational students were more likely to report high levels of soft drink consumption compared with higher-level education students. An Australian study on vocational students showed that inadequate physical activity rates were high and that as high as 33% of students were overweight or obese (22). From a health perspective, the differences between vocational and non-vocational students are problematic.

The health benefits of having a high physical activity level and high cardiorespiratory fitness (absolute VO_{2peak}) and not having a high body mass index (BMI) and not being overweight, are well established. International studies indicate that high physical capacity in adolescence reduces the risk of cardiovascular diseases in adulthood. For example, Alricsson et al. (20) pointed out the significant positive effect of physical activity on good health and the negative effect of overweightedness. A study on 11–19-year-old boys and girls showed that cardiorespiratory fitness was independent and positively associated with physical activity (23), whereas another study (24) found that persistent inactivity during adolescence was associated with poorer cardiorespiratory fitness during adolescence. Research studies have shown that high levels of physical activity and cardiorespiratory fitness, have positive effects in relation to cardiovascular morbidity and mortality, and that low levels of physical activity and cardiorespiratory fitness are positively related to risk factors for cardiovascular diseases such as diabetes, hypertension, site-specific cancers, bone health, and selected dyslipidemias (2, 3, 25, 26). Physical activity also has a positive effect on overweightedness (20, 27). The benefits of physical activity appear early in life and lead to positive changes in adiposity, skeletal health, psychological health, and cardiorespiratory fitness (4). Differences in the frequency of somatic and psychological symptoms between overweight and normal-weight adolescents represent medically and socially negative consequences. A review concluded that there are significant and positive associations between physical activity levels and physical fitness and that negative relationships between body fat and performance exist in both endurance and weight-bearing tasks, whereas flexibility does not seem to differ significantly between overweight or obese children and normal-weight peers (28).

Adolescents who become white-collar professionals in Norway (as in other countries), take a specialization in general studies as a first stage to qualify for work, whereas adolescents who become blue-collar professionals generally take vocational subjects in high school to qualify for vocational work. A literature search indicates a lack of longitudinal studies about the development of absolute VO_{2peak} , BMI, overweightedness, and physical activity level in adolescents in vocational and those in non-vocational studies. Two reasonable questions that spring forth are how early differences in relation to physical activity level, cardiorespiratory fitness, and weight status begin, and of which of these factors are the differences significant. Such knowledge is important to be able to prevent group differences according to health-related variables, and between vocational and non-vocational students. The present research project provides data from the same students each year at 14–19 years of age. The aim was to examine longitudinal changes in absolute VO_{2peak} , BMI, overweightedness, and physical activity level in adolescents enrolled in one of the three main fields of study in high school in Norway (sport studies, vocational subjects, and specialization in general studies). The purpose of the study was to identify group differences according to physical fitness, physical activity level, and overweight, but also examine whether physical activity level and physical fitness may explain differences in overweight. Such knowledge is important to be able to prevent overweightedness in exposed groups. The

available data include measures from the year the students started in lower secondary school in Norway at 14 years of age until they finished high school at 19 years of age. The research questions are as follows: Are there differences between students enrolled in sport studies, vocational subjects, and specialization in general studies in relation to absolute $\text{VO}_{2\text{peak}}$, physical activity level, BMI, and overweightedness? If so, do these differences increase, decrease or stay the same?

MATERIALS AND METHODS

Design

A longitudinal design with repeated measures of students during secondary school—from the year they started lower secondary school at 14 years of age to their final year of high school at 19 years of age—was used to examine the research questions. Peak oxygen uptake, activity level, weight, and height were measured at the pretest phase (eighth grade, 14 years of age) and then retested each year for a 5-year period. Measures of weight and height were used to calculate the BMI values, and these values were then used to calculate obesity.

Subjects

The data were based on 116 eighth-grade students in six classes (three teams of two classes) at two schools (mean; age = 14 ± 0.5 years, weight = 54.2 ± 10.9 kg, height = 1.63 ± 0.08 m). The classes were randomly selected for the study from a small city in central Norway. The distribution of boys and girls was relatively equal in the sample (61 boys and 55 girls), as well as the distribution of urban and rural students. The numbers of students with valid test results during the data collection were as follows: 105 students in eighth grade (14 years old), 103 in students in ninth grade (15 years old), 106 students in 10th grade (16 years old), 79 students in first year of high school (17 years old), 65 students in second year of high school (18 years old), and 76 students in third (and last) year of high school (19 years old). The invalid data were attributed to students dropping out because of illness, injury, pregnancy, or relocation. Because some subjects dropped out during testing in ninth grade and the first and second years of high school, we decided to include data only from the students when they were 14, 16, and 19 years old. With such a strategy, 81 subjects (70% response rate) were included in the entire analysis, except for the accelerometer data. Of these 81 subjects, 31 subjects (16 girls and 15 boys) enrolled in vocational subjects in high school, 36 subjects (22 girls and 14 boys) enrolled in specialization in general studies in high school, and 14 subjects (two girls and 12 boys) enrolled in sport studies in high school. This distribution reflects the ordinary distribution of students in high school in a specific county.

The subjects were fully informed about the protocol before participating in this study, and a written informed parental consent was obtained. Approval to use the data and conduct the study at the high schools was given by the Norwegian Social Science Data Services and the Norwegian ethical regional comité.

Procedure

Peak oxygen uptake (absolute $\text{VO}_{2\text{peak}}$, $\text{L}\cdot\text{min}^{-1}$, $\text{mL}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$, and $\text{mL}\cdot\text{g}^{-0.67}\cdot\text{min}^{-1}$), weight and height were measured during the period of February–April each year, from when the students were aged 14 years until they were aged 19 years (at the end of high school). All tests were carried out by the same test leader, in the same laboratory, with the same equipment, and with the same procedures.

Oxygen uptake measurements were carried out on a Woodway S5 treadmill (Woodway, Waukesha, WI, USA). The number of persons in the test lab was limited to the test leader and one student so as to keep the oxygen level in the air stable and to avoid disturbances during testing. Prior to testing, the students were given information about the test conditions (avoid strenuous exercise the day before; eat 2–3 h before testing, only a “light” breakfast; limit participation in physical education before testing to only light activity). The test outfit consisted of running shoes, shorts or training pants, and a T-shirt or jumper. Oxycon Pro (Erich Jaeger GmbH, Hoechberg, Germany) was used to measure oxygen uptake. According to the test procedure, an incline of 10.5% was used on the treadmill so as to prevent the running technique from being a limiting factor for the maximal oxygen uptake. Before the test, the students were asked how much they trained. Girls who did not train or were obese started with a speed of 4 km h^{-1} , those who trained one to two times a week started with a speed of 5 km h^{-1} , and those who trained three to four times a week started with a speed of 6 km h^{-1} . For boys, the same categories were used but at a 1 km h^{-1} higher speed. This procedure was carried out at the first test when the subjects were aged 14 years. At retests, the start speed was 3–4 km h^{-1} lower than the highest speed on the previous year’s test. The speed on the treadmill was increased by 1 km h^{-1} every minute, except sometimes at the end of the test, when the speed was increased by only 0.5 km h^{-1} . The criterion for the highest maximal oxygen uptake was a flattening/decrease of the O_2 curve with increasing speed (respiratory exchange ratio > 1.00). The average measure of the two highest measurements that occurred consecutively was recorded as the maximal oxygen uptake. The test had a duration time of 5–6 min.

Height was measured with a measuring tape that was permanently attached to the wall. The subjects did not wear shoes, and height was measured to the nearest centimeter. Weight was measured with a Seca digital scale, which is accurate to 0.1 kg. BMI was calculated by dividing weight (kilogram) by height (centimeter) squared and then multiplying the result by 10,000, in relation to international standards (29). The cut-off values for overweightedness were set at 22.62 for boys and 23.34 for girls at 14 years of age, 23.90 for boys and 24.37 for girls at 16 years of age, and 25 for all adolescents at 19 years of age.

At the end of the test protocol, the students answered a questionnaire. The following question about physical activity level was also included: “How many days a week are you physically active that you become sweaty or out of breath?” The response options were “never,” “one day a week,” “2–3 days a week,” “4–5 days a week,” and “6–7 days a week.” This variable was dichotomized into a variable with less than 4 days a week and with 4 days a week or more.

Statistical Analysis

To identify differences between students in sport studies, students in vocational subjects, and students with a specialization in general studies in relation to absolute VO_{2peak} , BMI, and physical activity level (accelerometer), we carried out a repeated measures analysis of variance. The effect size was evaluated with η^2_p (partial eta-squared), where $0.01 < \eta^2 < 0.06$ indicates a small effect; $0.06 < \eta^2 < 0.14$, a medium effect; and $\eta^2 > 0.14$, a large effect (30). If the analyses showed significant differences, *post hoc* tests with Bonferroni corrections were performed. The Kruskal–Wallis test (a non-parametric test) was used to identify group differences according to overweightedness and self-reported physical activity level, whereas the Friedman test (a non-parametric test) was used to identify significant changes in these variables during the period. The level for significance was set at $p < 0.05$. Statistical analysis was performed with SPSS, version 23.0 (IBM, Armonk, NY, USA).

RESULTS

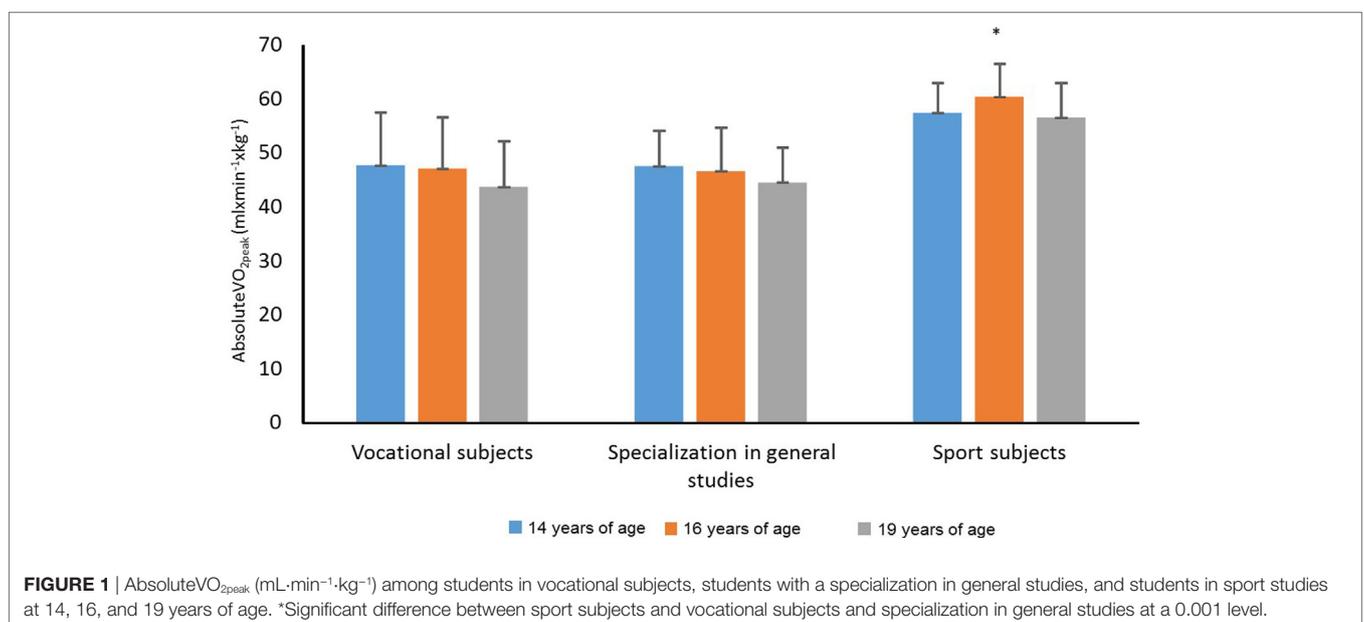
Figure 1 shows a significant decrease in the absolute VO_{2peak} (milliliter per minute per kilogram) over time from 14 until 19 years of age ($F_{2,156} = 14.928$, $p = 0.000$, $\eta^2 = 0.161$, $1 - \beta = 0.998$). There was also a significant main effect of line of study on the absolute VO_{2peak} (milliliter per minute per kilogram) ($F_{2,78} = 15.304$, $p = 0.000$, $\eta^2 = 0.282$, $1 - \beta = 0.999$). However, there was no significant interaction between time and line of study ($F_{4,156} = 1.456$, $p = 0.239$, $\eta^2 = 0.036$, $1 - \beta = 0.303$). Follow-up analyses showed that absolute VO_{2peak} (milliliter per minute per kilogram) dropped significantly from 16 to 19 years of age (mean difference = $3.1 \text{ mL}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$, 95% CI = -4.5 to -1.7 , $p < 0.001$). From 14 to 19 years of age, the maximal oxygen uptake (milliliter per minute per kilogram) dropped by an average of $2.6 \text{ mL}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$ (95% CI = -4.4 to -0.9 , $p = 0.001$). Furthermore, absolute VO_{2peak} (milliliter per minute

per kilogram) was significantly higher among students in sport studies than students in vocational subjects (mean difference = $11.9 \text{ mL}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$, 95% CI = 6.1 – 17.7 , $p < 0.001$) and students with a specialization in general studies (mean difference = $11.9 \text{ mL}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$, 95% CI = 6.2 – 17.5 , $p < 0.001$).

The analysis showed that the percentages of physically active students did not change during the period among students in vocational subjects ($\chi^2_2 = 1.400$, $p = 0.497$), students with a specialization in general studies ($\chi^2_2 = 0.364$, $p = 0.834$), and students in sport subjects ($\chi^2_2 = 2.000$, $p = 0.368$). The percentages of physically active students were significantly different with regard to the line of study at 14 years of age ($\chi^2_2 = 8.721$, $p = 0.013$), at 16 years of age ($\chi^2_2 = 11.933$, $p = 0.003$), and at 19 years of age ($\chi^2_2 = 15.163$, $p = 0.001$). **Figure 2** shows that students in sport subjects were more physically active than other students.

Figure 3 shows a significant increase in BMI over time from 14 until 19 years of age ($F_{2,156} = 81.936$, $p = 0.000$, $\eta^2 = 0.512$, $1 - \beta = 1.000$). There was no significant main effect of line of study on BMI ($F_{2,78} = 1.331$, $p = 0.270$, $\eta^2 = 0.033$, $1 - \beta = 0.279$). Furthermore, there was no significant interaction between time and line of study ($F_{4,156} = 1.561$, $p = 0.187$, $\eta^2 = 0.078$, $1 - \beta = 0.474$). Follow-up analyses showed that BMI increased significantly from 14 to 16 years of age (mean difference = 1.504 BMI, 95% CI = -2.0 to -1.0 , $p < 0.001$) and from 16 to 19 years of age (mean difference = 1.626 BMI, 95% CI = -2.2 to -1.1 , $p = 0.000$).

The analysis showed that the percentage of students classified as overweight did not change during the period among students in vocational subjects ($\chi^2_2 = 4.909$, $p = 0.086$), students with a specialization in general studies ($\chi^2_2 = 2.000$, $p = 0.368$), and students in sport subjects ($\chi^2_2 = 3.000$, $p = 0.223$). The percentages of students classified as overweight did not differ significantly with regard to the line of study at 14 years of age ($\chi^2_2 = 3.436$, $p = 0.179$) or at 16 years of age ($\chi^2_2 = 4.956$, $p = 0.084$), but they were significantly different with regard to the line of study at 19 years of age ($\chi^2_2 = 8.502$, $p = 0.014$). **Figure 4** shows that students in



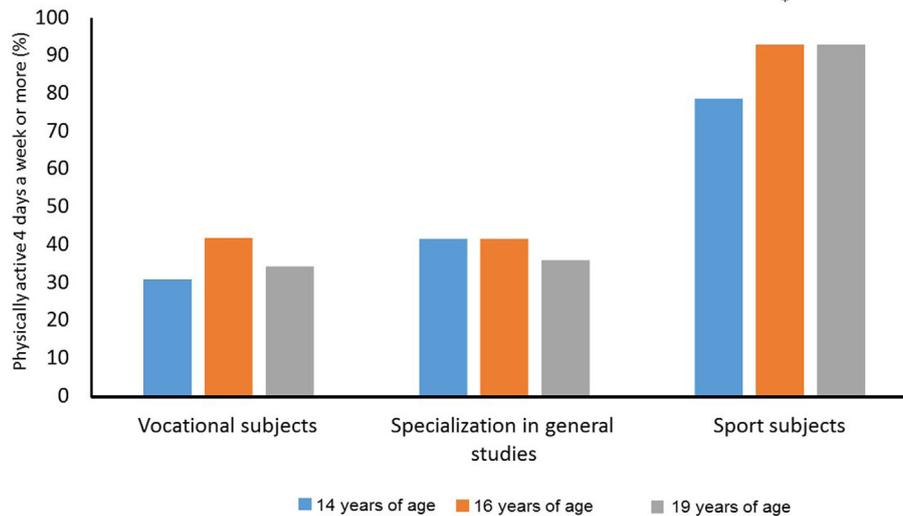


FIGURE 2 | Percentage of students who were physically active (4 days or more during an ordinary week) among students in vocational subjects, students with a specialization in general studies, and students in sport studies at 14, 16, and 19 years of age. *Significant difference between sport subjects and vocational subjects and specialization in general studies at a 0.05 level.

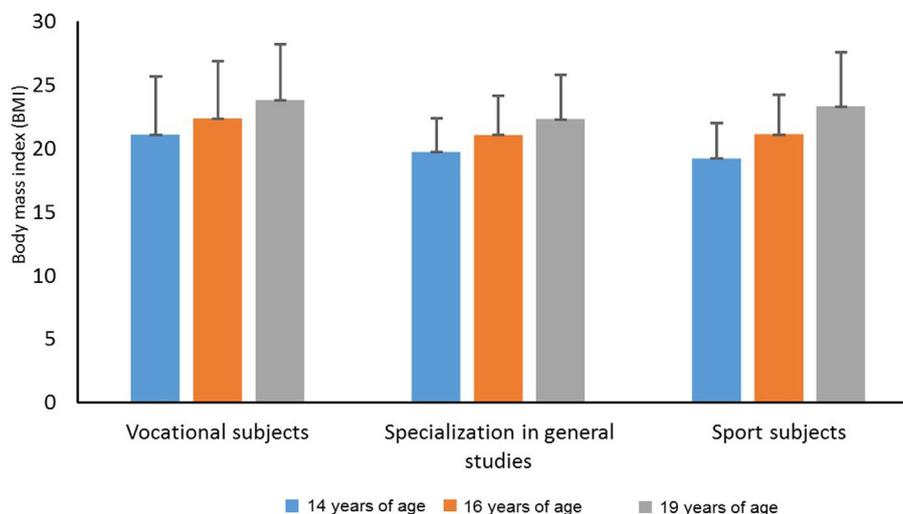


FIGURE 3 | Body mass index among students in vocational subjects, students with a specialization in general studies, and students in sport studies at 14, 16, and 19 years of age.

vocational subjects had a higher percentage of students classified as overweight than the other groups at 19 years of age.

DISCUSSION

Group Differences in Absolute VO_{2peak}

The results show significant decreases in the absolute VO_{2peak} milliliter per minute per kilogram from 14 years of age until 19 years of age. This is in line with Kemper et al. (31), who studied peak oxygen uptake and physical activity level of boys and girls from 12

to 36 years of age. In their study, they found that absolute VO_{2peak} ($mL \cdot min^{-1} \cdot kg^{-1}$) significantly decreased over the whole age range from 12 to 36 years of age in both sexes. In addition, Pfeiffer et al. (32) found a decrease in cardiorespiratory fitness among adolescents in a 4-year longitudinal study. However, other studies have found that cardiorespiratory fitness (absolute VO_{2peak} , $mL \cdot min^{-1} \cdot kg^{-1}$) seems to increase slightly or be stable over time among adolescents (9). Those findings indicate that adolescents' development of cardiorespiratory fitness is not linear and that the development of cardiorespiratory fitness varies according to age period.

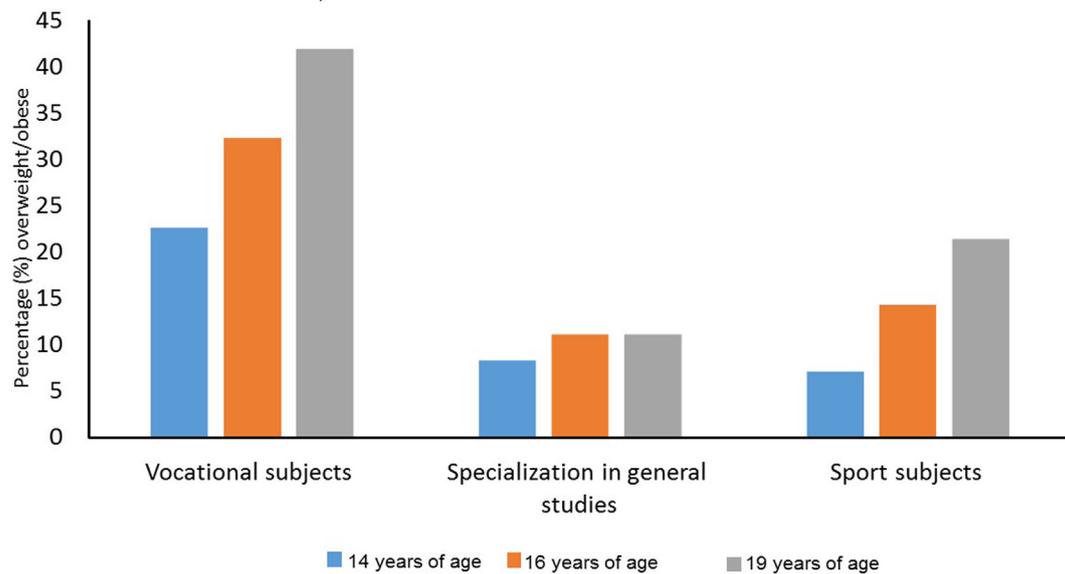


FIGURE 4 | Percentage of overweight students among students in vocational subjects, students with a specialization in general studies, and students in sport studies at 14, 16, and 19 years of age. *Significant difference between vocational subjects and sport subjects and specialization in general studies in 10th grade at a 0.05 level.

The results of the present study show that sport subject students had significantly higher absolute VO_{2peak} levels, than students in vocational subjects, and students with a specialization in general studies. However, there were no significant differences between students in vocational subjects and students with a specialization in general studies according to the absolute VO_{2peak} levels, and the development of these measures. An argument can easily be made that the higher absolute VO_{2peak} level and the increase in the absolute VO_{2peak} level among students in sport studies is natural and, hence, not surprising. These students specialize in sport and participate in several sport training sessions during a typical week, both at school and in their leisure time. The relatively high percentage of boys among the sport subject students also has a positive effect on the absolute VO_{2peak} level of these students (33). However, the absence of significant differences between students in vocational subjects and students with a specialization in general studies with regard to absolute VO_{2peak} levels is somewhat surprising, based on our hypothesis in section “Introduction,” considering that boys in general have higher oxygen uptake levels than female adolescents (33), and that the percentage of boys was higher among students in vocational subjects than students with a specialization in general studies.

Previous studies from Iceland and Sweden have indicated differences between vocational and non-vocational students. A study by Arngrimsson et al. (14) showed that vocational students had lower levels of fitness than non-vocational students. Alricsson et al. (13) found that students in vocational programs reported poorer self-related health than those in non-vocational programs. However, those reports are not necessarily associated with poorer physical fitness. Our findings suggest that this poorer self-related health may be related to overweightedness.

The lack of differences in relation to absolute VO_{2peak} levels between students in vocational subjects and students with a specialization in general studies is positive from a sociological point of view (17), and from a health perspective. The health benefits of high cardiorespiratory fitness (absolute VO_{2peak}) are well established (2, 3). International studies indicate that high physical capacity in adolescence reduces the risk of cardiovascular diseases in adulthood. Richards et al. (24) found that persistent inactivity during adolescence was associated with poorer cardiorespiratory fitness during adolescence. A high level of cardiorespiratory fitness has a positive effect in relation to cardiovascular morbidity and mortality, and a low level of cardiorespiratory fitness is positively related to several health-related risk factors (2, 3, 25, 26).

Physical Activity-Related Findings

The results from the self-reported physical activity (Figure 2) show that students in sport studies had a higher activity level than students in vocational subjects and students with a specialization in general studies. However, no significant difference was detected in the activity level between students in vocational subjects and students with a specialization in general studies. This finding is positive from a health perspective, because the health benefits of physical activity are well documented (1–3, 25, 26). Research has shown that the benefits of physical activity appear early in life, and lead to positive changes in adiposity, skeletal health, psychological health, and cardiorespiratory fitness (4).

Previous research has shown that cardiorespiratory fitness are positively associated with physical activity among adolescence at the age of 14–19 (17). The results in Figure 2 (no difference in activity level among students in vocational subjects and students

with a specialization in general studies), support the finding of no difference in cardiorespiratory fitness between these two groups. Another study showed that students in vocational programs had a lower level of activity compared with students in non-vocational programs (19). However, that study included all non-vocational students in one group and did not differentiate between students with a specialization in general studies and students in sport studies (the group with a high level of physical activity).

Previous research has identified the physical activity level to be one of the fundamental factors associated with adolescents health (1–4). The analyses in **Figure 2** show no significant differences in activity level according to age. However, several other studies indicate that adolescents physical activity level seems to decrease over time in general (5–7). Belanger et al. (5) found that the prevalence of participation by adolescents in most activities declined over a 5-year period; it did not increase for any activity. Andersen (10) found that changes in physical performance between 16 and 18 years of age very similar in different countries, despite differences in physical activity patterns, and absolute level of performance. Different definitions of physical activity level may explain the conflicting results.

Group Differences Related to Weight

The results show significant increases in BMI over time, from 14 until 19 years of age. There were no significant main effects of line of study on BMI, and no significant interaction was detected between time and line of study on BMI.

The analysis shows that the percentages of students classified as overweight/obese did not change in the three groups of students during the period of study. Furthermore, the percentage of students classified as overweight did not differ significantly with regard to the line of study at 14 years of age or at 16 years of age. The percentage of adolescents classified as overweight among all 81 subjects at the age of 19 (24.7%), is nearly the same as in another study with the same age group among Icelandic students (14). Bovet et al. (15) found that the prevalence of overweightedness among children (12–15 years old) in the Republic of the Seychelles was approximately 15%. Also a study among Norwegian children (4–15 years old) found a lower prevalence of overweightedness (approximately 19%). However, these studies included younger children, and **Figure 4** show that overweightedness seems to increase by age.

However, in the present study, students in vocational subjects were significantly more overweight/obese at 19 years of age compared with sport subject students and students with a specialization in general studies. We argue that our findings indicate that overweightedness is a major issue among vocational students in Norway, as is the case in the Netherlands (16). The difference between vocational and non-vocational students is problematic from a health perspective. Whereas 12.5 and 21.4% of students with a specialization in general studies and students in sport subjects, respectively, were categorized as overweight/obese, 41.9% of students in vocational subjects were categorized as overweight/obese at 19 years of age. **Figure 4** shows that as high as 22.6 and 32.3% of the students in vocational subjects, were categorized as overweight/obese at 14 and 16 years of age, respectively. These values are higher compared with sport subject students and students with a specialization in general studies,

with only 7.1–14.3% being categorized as overweight/obese at these measure times.

Our findings support other research studies that pointed to overweightedness as being more widespread among adolescents in vocational programs than in non-vocational programs (13, 21). In addition, our findings support research studies that highlighted major concerns regarding differences in health-related behavior in relation to different occupations (17). Bourdieu's theory of habitus may explain why overweightedness is influenced by education level (18). An Australian study on vocational students showed that 33% of the students were overweight or obese (22). As **Figure 4** in our study shows, the percentage of students categorized as overweight/obese is even higher among students in vocational subjects. It is difficult to explain why more vocational students are overweight, but our findings suggest that it is not because of lower activity level or lower physical fitness. Thus, differences in consumption of food and drink may be a possible explanation. van der Horst et al. (21) also found that vocational students were more likely to report high levels of soft drink consumption compared with non-vocational students. The health benefits of not being overweight or obese, are well documented (20, 28). Overweightedness among adolescents has medically and socially negative consequences (28). Although research has reported cardiorespiratory fitness to be lower in overweight groups than in those of normal weight (34), other research has also emphasized that being overweight or obese is not necessarily associated with poor physical fitness and that it is not always caused by a sedentary lifestyle (12). Obesity may be a result of genetic, cultural, and neurobiological mechanisms.

CONCLUSION

A literature search indicates a lack of longitudinal studies on the development of physical activity level, physical fitness, and weight-related factors among adolescents in vocational and non-vocational high school study programs. The present study, which focuses on students in sport studies, students in vocational subjects, and students with a specialization in general studies from 14 to 19 years of age, shows that students in sport studies had higher levels of absolute VO_{2peak} and physical activity than students in vocational subjects, and students with a specialization in general studies. However, no significant differences in levels of absolute VO_{2peak} and physical activity were detected between students in vocational subjects and students with a specialization in general studies.

The results show significant increases in BMI over time for each group but no group differences and interactions. Furthermore, the analysis showed that the percentages of students classified as overweight/obese did not change during the period for the three groups of students and with regard to the line of study at 14 years or at 16 years of age. However, students in vocational subjects were significantly more overweight/obese at 19 years of age compared with students in sport studies and students with a specialization in general studies.

Our findings support other research studies that point to overweightedness as being more widespread among adolescents in vocational programs than in non-vocational programs.

Furthermore, our study indicates that food and drink consumption—not physical activity level or cardiorespiratory fitness—may explain the high proportion of overweightedness among vocational students. We recommend that further studies with a larger sample size be carried out to examine differences between vocational and non-vocational students in physical activity level, physical fitness, and weight-related factors. Further studies should also examine food and drink consumption among vocational and non-vocational students to identify reasons for differences in overweightedness.

ETHICS STATEMENT

The subjects were fully informed about the protocol before participating in this study, and a written informed parental

consent was obtained. Approval to use the data and conduct the study was given by the Norwegian Social Science Data Services (NSD) and the Norwegian ethical regional comité.

AUTHOR CONTRIBUTIONS

PL has contributed on design and methods, writing the introduction, methods, discussion, and the conclusion. Furthermore, a critical review of all the text during several numbers of the article and rewriting of the text. OF has contributed on design and some minor contribution on writing the introduction, discussion, conclusion, and a critical review of the text. IM has contributed on writing the introduction, discussion, and conclusion. Furthermore, a critical review of all the text during several numbers of the article and rewriting of the text.

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