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The Importance of Adolescents' Participation in Organized Sport According to VO₂peak: A Longitudinal Study

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ABSTRACT

Research from several countries has documented a decline in physical activity (PA) levels and in participation in organized sport with increasing age, indicating that organized sport may be of importance to adolescents' cardiorespiratory fitness (CRF). **Purpose:** The purpose of this study was to examine how regular participation in organized and unorganized PA affected the development of adolescents' CRF (peak oxygen consumption [VO₂peak]), when controlled for sex interaction. **Method:** Data on direct measures of VO₂peak and participation in organized PA among adolescents organized into 3 groups (participation in organized sport, participation in unorganized PA, and no weekly PA) were collected from 76 students (39 boys and 37 girls), when they were aged 14 and 19 years old. **Results:** Statistically significant differences were found between VO₂peak values in the 3 groups at both 14 years of age, $F(2, 73) = 7.16, p < .05, \eta^2 = .170$, and 19 years of age, $F(2, 73) = 14.00, p < .05, \eta^2 = .300$, independent of sex at both 14 and 19 years of age, $F(2, 73) = 0.05, p > .05, \eta^2 = .02$, and $F(2, 73) = 0.05, p > .05, \eta^2 = .00$. Adolescents participating in organized sport also had statistically significantly higher VO₂peak values than adolescents participating in unorganized PA and those with no weekly PA, at both 14 and 19 years of age. **Conclusion:** From a health perspective, in terms of CRF, the findings highlight the importance of encouraging adolescents to participate in organized sport and to refrain from dropping out of organized sport programs.

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The cardiovascular health benefits of physical activity (PA) and cardiorespiratory fitness (CRF) are well established. Both have inverse relationships with cardiovascular morbidity and mortality and with risk factors for cardiovascular diseases, such as diabetes, hypertension, site-specific cancers, bone health, and selected dyslipidemias (Anderssen et al., 2007; DeFina et al., 2015; Myers et al., 2015; Ortega, Ruiz, Castillo, & Sjöström, 2008). Data have also shown that poor CRF is strongly associated with cardiovascular diseases in children, and this relationship was stable across countries, age, and sex (Anderssen et al., 2007). The positive effects of PA appear early in life, with regular participation in PA during childhood producing numerous immediate benefits, including positive changes in adiposity, skeletal health, psychological health, and CRF. The benefits of PA during childhood also appeared to have a positive influence on adult health outcomes, such as increased bone mineral density (Loprinzi, Cardinal, Loprinzi, & Lee, 2012).

Children and adolescents partake in many different types of PA, from unorganized PA, including walking to and from school, active travel, and participating in

unstructured outdoor play, to organized sport. Type of PA is of particular importance because a rather dramatic change in PA occurs between childhood and late adolescence. Part of this change concerns the level of PA, with research indicating that participation in almost all types of PA declines during adolescence (Bélanger, Gray-Donald, O'Loughlin, Paradis, & Hanley, 2009). Numerous studies in several countries have documented the decline in general PA and participation in organized sport with increasing age (Bélanger et al., 2009; Kolle, Stokke, Hansen, & Anderssen, 2012; Riddoch et al., 2004; Telama & Yang, 2000). However, the decline in PA with increasing age must not be confused with a historical shift in Norwegian youth becoming less active. Among youth (aged 15–20 years old), a clear and steady increase has occurred in the number of youth reporting to be medium and highly physically active in the time period of 1985 to 2013 (Seippel, 2017). During the same time period, a corresponding decrease took place in the number of youth reporting low PA.

Another component of the change in PA is the shift in type of PA throughout adolescence, which is

characterized by young people dropping out of organized sport in favor of commercial PA (gym and fitness centers) and unorganized PA (Seippel, 2017). According to Green, Thurston, Vaage, and Roberts (2015), Norway is characterized by particularly high levels of sport participation and membership in organized sport. In fact, it has been estimated that 85% of all children in Norway are members of organized sport and most begin their membership prior to 10 years of age. However, there exists a large dropout rate with increasing age, with the apex of leaving organized sport occurring at the age of 16 years (Støckel, Strandbu, Solenes, Jørgensen, & Fransson, 2010).

This high dropout rate is important because several studies have indicated that organized sport seems to be of particular importance when investigating the relationship between youth PA and adult PA. For example, Telama, Yang, Hirvensalo, and Raitakari (2006) found that participation in youth sport and sport competitions significantly predicted adult PA. Aarnio, Winter, Peltonen, Kujala, and Kaprio (2002) found that adolescents who participated in organized sport were also more often persistent exercisers than those who did not participate in organized sport. In addition, Santos, Gomes, and Mota (2005) demonstrated that active participants reported significantly more participation in organized sport than did their nonactive counterparts. In the Norwegian context, a longitudinal study showed that participation in organized sport during childhood and adolescence was positively related to frequency of leisure-time PA in young adulthood (Kjønniksen, Anderssen, & Wold, 2009). The authors concluded that joining organized youth sports at an early age and continuing through adolescence appeared to increase the likelihood of having a physically active lifestyle in young adulthood.

Based on the decline in PA and the importance of organized sport as a contributor to health (Khan et al., 2012; Perkins, Jacobs, Barber, & Eccles, 2004), it is reasonable that adolescence has been identified as a critical time for PA participation. The habits that develop during this time may persist into adulthood (Hallal, Victora, Azevedo, & Wells, 2006; Murphy, Rowe, & Woods, 2016). A physically active lifestyle as an adolescent will affect one's physical fitness because PA exhibits a significant and positive association with physical fitness (Marta, Marinho, & Marques, 2012).

Peak oxygen uptake (VO_{2peak}), which is recognized to constitute the best single measure of young people's aerobic fitness, increases with age and maturation. Because VO_{2peak} ($mL \cdot min^{-1} \cdot kg^{-1}$) is highly correlated to body mass, it may be an optimal indicator of physical fitness (Åstrand, Rodahl, & Strømme, 2003). A

certain intensity of PA is necessary to increase VO_{2peak} , which may explain the positive relationship between VO_{2peak} and a high PA level and sport participation (Armstrong, Tomkinson, & Ekelund, 2011; Kemper, Twisk, & van Mechelen, 2013). This increase in VO_{2peak} continues until approximately 14 years of age for girls and 17 years of age for boys, and in general, boys' VO_{2peak} values are greater than those of girls (Armstrong et al., 2011; Kemper et al., 2013). In addition, boys' VO_{2peak} values remain remarkably consistent from 6 to 18 years of age, whereas girls exhibit a steady decrease in VO_{2peak} values (Armstrong et al., 2011).

Even though no compelling evidence exists to suggest that young people have historically low levels of VO_{2peak} , there appears to have been a historical decline in young people's aerobic performance on a global scale, including in the Norwegian context. Aires et al. (2012) analyzed longitudinal associations between CRF and PA and found independent associations between CRF and PA regarding participation in organized sport, unorganized PA, and participation in sports competitions for girls. In boys, associations were identified only with participation in sports competitions. These results highlighted the importance of adolescent participation in organized sport over time in the achievement of health-related fitness benefits. In addition, Pfeiffer, Dowda, Dishman, Sirard, and Pate (2007) reported that sport participants exhibited an increase in CRF over time, and that PA and sport participation were major factors related to change in CRF over time. However, not all studies support a strong relationship between participation in organized sport and physical fitness. For example, in a 2-year longitudinal study of 16-year-old students, Andersen (1996) found that a change in PA or sports activity did not relate to a change in physical fitness level. Specifically, the relationships between sport participation and physical fitness measured at baseline and Time 2 were weak or nonsignificant. The author offered three explanations for the weak relationship between PA and fitness: genetics, growth and hormonal changes, and a high physical fitness level at baseline.

Knowledge about how regular participation in organized sport, participation in unorganized PA, or no regular PA at all affects the development of physical fitness among adolescents, is critical. We acknowledge that the PA pattern changes during adolescence and that an important part of this change is choosing other types of PA over organized sport. Dropping out of sport does not seem to result in inactivity. However, because a documented relationship exists between organized sport and CRF, it is worth investigating whether

choosing unorganized PA over organized sport will have an impact on CRF. Thus, the aim of the present study was to examine how regular participation in organized sport and unorganized PA affects the development of VO₂peak among adolescents aged 14 to 19 years of age, while controlling for sex differences.

Materials and methods

Design

We endeavored to fulfill the research aim by utilizing data from a larger research project that included measures of VO₂peak and participation in organized and unorganized PA from eighth grade to the 3rd year of high school.

Participants

The data were based on 116 eighth-grade students in six classes (three groups with two classes per group) at two schools ($M_{\text{age}} = 14 \pm 0.5$ years, $M_{\text{weight}} = 54.2 \pm 10.9$ kg, $M_{\text{height}} = 1.63 \pm 0.08$ 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 was the distribution of urban and rural students.

Only 48 students had valid data for all six measurement times, which constituted a response rate of only 41%. Seventy-six students (39 boys and 37 girls) completed the fitness test and reported their PA pattern at the start of data collection in the eighth grade (14 years old) and at the end of the data collection in the 3rd year of high school (19 years old). This number constituted a response rate of 66%, and we decided to also include these students in the analysis. Invalid data occurred when students dropped out of the study. Reasons for dropping out were illness, injury, pregnancy, relocation, failure to meet to take the test, and failure to answer all the questions on the questionnaire.

The participants were fully informed about the protocol before participating in this study. Participant assent and parental consent were obtained. Approval to use the data and conduct the study was granted by the Norwegian Social Science Data Services and the Ethical Regional Committee in Mid-Norway.

Procedure

A questionnaire about participation in organized sport and unorganized PA and a physical fitness test (VO₂peak) were conducted on each participant at the same time during the time that the participants were at

school. The data collection was carried out during a 2-month period (April–May, 2010) annually from the eighth grade until the 3rd year of high school (2015). All tests and measurements were performed in the same room with identical test procedures, the same test equipment, and the same test leader for all 6 test years.

Oxygen uptake measurements were conducted on a Woodway S5 treadmill (Woodway, Waukesha, WI). The number of people in the test laboratory was limited to the test leader and one student to keep the oxygen level in the air stable and to prevent disturbances during the tests. Prior to testing, the students were given the following information about the test conditions: Avoid strenuous exercise the day before testing, eat 2 hr to 3 hr before testing, eat only a “light” breakfast, and limit participation in PA before testing to only light activity. The test outfits worn by the participants consisted of running shoes, shorts or training pants, and a T-shirt or jumper. Oxygen uptake was measured with the Oxycon Pro (Erich Jaeger GmbH, Hoechberg, Germany). To prevent the participants’ running technique from being a limiting factor for maximal oxygen uptake, we set the treadmill at an incline of 10.5%, according to the test procedures. Prior to the test, the students were asked how much they trained. Girls who did not train or who were obese started at a speed of 4 km/hr; those who trained one to two times a week started at a speed of 5 km/hr; and those who trained three to four times a week started at a speed of 6 km/hr. The same categories were used for boys, but the starting speed was set 1 km/hr higher for each category. The speed on the treadmill was increased by 1 km/hr every minute, except sometimes at the end of the test when the speed was increased by only 0.5 km/hr. The criterion for the highest maximal oxygen uptake was a flattening/decrease of the O₂ curve with increasing speed (respiratory exchange ratio > 1.00). The average of the two highest consecutive measurements was recorded as the maximal oxygen uptake. The test had a duration time of 5 min to 6 min. The VO₂peak levels were used to categorize the adolescents as unfit (low fitness), according to the standards of Ruiz, Cavero-Redondo, Ortega, and Welk (2016).

Height was measured with a stadiometer (kawe medizintechnik seit 1890, Kirchner & Wilhelm, Asperg, Germany), which was permanently attached to the wall. The participants did not wear shoes, and height was converted to the nearest centimeter. Weight was measured with a Seca Digital weight (gmbh & co, Hamburg, Germany, Model 877; accuracy of 0.1 kg). Body mass index (BMI, kg/m²) was calculated, and overweight categorization was defined as a BMI greater

than 22.62 for boys and 23.34 for girls at age 14 years and a BMI of 25 for all participants at 19 years of age, in relation to international standards (Cole, Bellizzi, Flegal, & Dietz, 2000).

The students ended the test by answering a validated questionnaire previously used among adolescents concerning PA participation in both organized and unorganized sports (Aspvik, Sæther, & Ingebrigtsen, 2008). The following two questions were included in the questionnaire: “During the season, how often do you participate in organized sport?” and “During the season, how often do you participate in unorganized physical activity?” In high school, a question about the students’ participation at fitness centers was included. The reply options to the questions were as follows: never, rarely, 1 to 3 days a month, 1 day a week, 2 to 3 days a week, 4 to 6 days a week, and every day. The cutoff for regular participation was set at weekly participation. Furthermore, the questionnaire included the following question about the students’ activity levels during the previous 4 weeks:

When you think about your physical activity during the past 4 weeks, how often did you participate in sport/exercise or other physical activity with such an intensity that you breathed fast, you sweat, or your heart beat fast for 20 min?

The reply options were as follows: never, less than once a week, once a week, 2 to 3 days a week, and most days of the week. In the questionnaire, it was pointed out that this activity included both activity at leisure and at school.

Statistical analysis

Independent *t* tests were used to identify differences between sex according to height, weight, and BMI, while the Mann Whitney *U* nonparametric test was utilized to identify differences between genders according to overweight and PA levels. Independent *t* tests were used to discern differences in absolute VO₂peak between the participants included in the analysis and the dropout students—at the pretest, the retest, and according to the development of absolute VO₂peak. One-way analysis of variance (ANOVA) was used to identify differences between the three groups (organized sport, unorganized PA, and no weekly participation) according to height, weight, and BMI, with post-hoc tests using Bonferroni corrections. The Kruskal Wallis nonparametric test was employed to identify differences between the three groups according to overweight and PA level, while the Mann-Whitney *U* test was performed in follow-up tests to discern pairwise

differences between the three groups. Furthermore, repeated-measures ANOVA was utilized to identify differences in absolute VO₂peak and the development of absolute VO₂peak between the participants included in the analysis and the dropout students. A two-way ANOVA was used to identify differences in absolute VO₂peak among the three groups (organized sport, unorganized PA, and no weekly participation) at 14 years of age and 19 years of age and to discern interactions between boys and girls in these three groups. A univariate ANOVA was used to identify changes in these three groups during the period from 14 years to 19 years of age (intercept) and to identify differences in the development of VO₂peak (mL·min⁻¹·kg⁻¹) among these three groups from 14 to 19 years of age. The effect size was evaluated with η^2_p (partial eta-squared), where $.01 < \eta^2 < .06$ indicated a small effect, $.06 < \eta^2 < .14$ indicated a medium effect, and $\eta^2 > .14$ indicated a large effect (Cohen, 1988). We used descriptive analyses (means and standard deviations) to present the results. Statistical significance was set at $p < .05$. Statistical Package for the Social Sciences Version 24 was used to perform the analyses.

An important question was whether there were differences among the 76 participants with valid measurements who were included in the analyses and the students who did not have valid data in eighth grade ($n = 40$) and the 3rd year of high school (because of a lack of response on their organization of PA, $n = 12$)—in other words, whether dropouts occurred at random. Statistical analyses revealed significant differences in absolute VO₂peak between the participants included in the analysis and the dropout students when they were in eighth grade ($t = -2.36$, $p < .05$). The 76 participants included in the study had a higher absolute VO₂peak ($M = 49.5$, $SD = 8.7$) than the 40 dropout students ($M = 45.6$, $SD = 7.3$). However, there were no statistically significant differences in absolute VO₂peak between the 76 participants included in the analysis and the 12 dropout students with valid absolute VO₂peak measures in the 3rd year of high school ($t = -1.89$, $p > .05$). Furthermore, no statistically significant differences existed in the development of absolute VO₂peak between the participants included in the analysis and the 12 dropout students ($t = -1.95$, $p > .05$).

Results

The characteristics of the participants included in this study are presented in Table 1. This table shows increases in BMI and the percentage of participants classified as overweight as well as a decrease in VO₂peak.

Table 1. Characteristics of the girls ($n = 37$) and boys ($n = 39$) who completed the fitness test at 14 and 19 years of age.

	14 years of age		19 years of age	
	Girls, <i>M</i> (<i>SD</i>)	Boys, <i>M</i> (<i>SD</i>)	Girls, <i>M</i> (<i>SD</i>)	Boys, <i>M</i> (<i>SD</i>)
Age	13.8 (0.4)	13.8 (0.4)	18.8 (0.4)	18.8 (0.4)
Height, cm	162.62 (7.29)	165.44 (9.45)	166.78 (5.88)	182.32 (7.87)
Weight, kg	56.12 (13.39)	52.66 (9.36)	64.94 (13.05)	76.17 (13.8)
BMI	21.06 (4.17)	19.11 (2.54)	23.22 (4.11)	22.88 (4.13)
Overweight, %	16.2	7.7	24.3	25.6
VO ₂ peak, mL·min ⁻¹ ·kg ⁻¹	43.98 (7.78)	54.69 (6.03)	40.16 (6.10)	52.21 (6.67)
VO ₂ peak, L·min ⁻¹	2.40 (0.41)	2.87 (0.53)	2.57 (0.41)	3.96 (0.75)
PA level	4.30 (0.66)	4.36 (0.67)	3.78 (1.00)	3.92 (0.87)
Unfit (low fitness), %	13.5	2.6	10.8	5.1

Note. BMI = body mass index; VO₂peak = peak oxygen consumption; PA = physical activity. PA: 1 = never, 2 = less than once a week, 3 = once a week, 4 = 2 to 3 days a week, 5 = most days of the week.

Table 2 shows that VO₂peak (mL·min⁻¹·kg⁻¹) varied and changed differently in relation to how the adolescents organized their weekly PA. The VO₂peak values of the groups at 14 years of age revealed that the following groups had the highest VO₂peak: adolescents who participated in organized and unorganized activity at both 14 years of age and 19 years of age (Group 1), those who participated in organized activity at 14 years of age, those who participated in organized and unorganized activity at 19 years of age (Group 5), and those with no weekly activity at both 14 years of age and 19 years of age (Group 10). However, the adolescents with no weekly activity at both 14 years of age and 19 years of age (Group 10) exhibited the highest decrease in their VO₂peak among all the groups. The following groups had the lowest VO₂peak: those who participated in unorganized activity at both 14 years of age and 19 years of age (Group 8), those with no weekly activity at 14 years of age, those who participated in unorganized activity at 19 years of age (Group 9), those who participated in organized and unorganized activity at 14 years of age, those with no weekly activity at 19 years of age (Group 4), those who participated in organized activity at 14 years of age, and those who participated in unorganized activity at 19 years of age (Group 6).

Table 2 shows that in relation to the change in VO₂peak values from 14 years to 19 years of age, the adolescents with no weekly activity at both 14 years of age and 19 years of age (Group 10) had the highest decrease in their VO₂peak of all groups, followed by those who participated in organized sport at 14 years and those with no weekly activity at 19 years of age (Group 7). The change from organized and unorganized activity at 14 years to no weekly activity at 19 years (Group 4) did not result in a large decrease in VO₂peak. A partial explanation may be that the VO₂peak value was relatively low at 14 years of age.

Table 2 indicates that participating in organized sport at both 14 years of age and 19 years of age may be critical to the achievement and maintenance of a high VO₂peak. To examine the VO₂peak values and changes in participants who participated in organized sport at both 14 years of age and 19 years of age, we merged Groups 1, 2, and 5 in Table 3 into an “organized sport” group ($n = 33$). Adolescents who participated in only unorganized PA at 19 years of age (Groups 3, 6, 8, and 9 in Table 3) were merged into “unorganized PA” ($n = 34$). Participants with no weekly participation at 19 years of age (Groups 4, 7, and 10 in Table 2) were merged into “no weekly participation” ($n = 9$).

Table 2. VO₂peak (mL·min⁻¹·kg⁻¹) and changes in VO₂peak in relation to adolescents' weekly participation in PA at 14 and 19 years of age ($N = 76$).

Organization of PA at 14 and 19 years of age	VO ₂ peak	VO ₂ peak	Change in VO ₂ peak 14–19 years old	<i>n</i>
	14 years old <i>M</i> (<i>SD</i>)	19 years old <i>M</i> (<i>SD</i>)		
1. Organized and unorganized at both times	54.7 (6.9)	52.4 (8.7)	-2.3 mL·min ⁻¹ ·kg ⁻¹	24
2. Organized and unorganized at 14 years, organized at 19 years	50.5 (8.0)	49.3 (8.4)	-1.2 mL·min ⁻¹ ·kg ⁻¹	5
3. Organized and unorganized at 14 years, unorganized at 19 years	48.9 (6.5)	43.5 (6.7)	-5.4 mL·min ⁻¹ ·kg ⁻¹	18
4. Organized and unorganized at 14 years, no weekly activity at 19 years	42.6 (12.8)	41.5 (8.0)	-1.1 mL·min ⁻¹ ·kg ⁻¹	3
5. Organized at 14 years, organized and unorganized at 19 years	54.4 (3.8)	53.5 (6.5)	-0.9 mL·min ⁻¹ ·kg ⁻¹	4
6. Organized at 14 years, unorganized at 19 years	43.2 (8.5)	38.4 (2.9)	-4.8 mL·min ⁻¹ ·kg ⁻¹	5
7. Organized at 14 years, no weekly activity at 19 years	47.8 (2.0)	40.7 (1.6)	-7.1 mL·min ⁻¹ ·kg ⁻¹	3
8. Unorganized at both times	41.5 (10.3)	41.4 (7.5)	-0.1 mL·min ⁻¹ ·kg ⁻¹	11
9. No weekly activity at 14 years, unorganized at 19 years	42.1	36.3	-5.8 mL·min ⁻¹ ·kg ⁻¹	1
10. No weekly activity at both times	54.8 (4.5)	46.7 (2.9)	-9.1 mL·min ⁻¹ ·kg ⁻¹	2

Note. VO₂peak = peak oxygen consumption; PA = physical activity.

Table 3. Characteristics of the participants categorized into three groups based on their PA (organized PA, unorganized PA, no weekly PA) at 14 and 19 years of age.

	Organized sport	Unorganized PA	No weekly PA
	<i>M</i> (<i>SD</i>) Boys/girls	<i>M</i> (<i>SD</i>) Boys/girls	<i>M</i> (<i>SD</i>) Boys/girls
<i>n</i>	22/11	14/20	3/6
14 years of age			
Age	13.8 (0.4)	13.8 (0.4)	13.8 (0.4)
Height, cm	167.6 (9.4)/162.1 (6.1)	163.8 (7.5)/163 (7.5)	156.8 (12.3)/161.7 (10.2)
Weight, kg	53.6 (10.4)/51.5 (7.5)	53.3 (6.5)/59.4 (15)	42.9 (9.8)/52.6 (14.8)
BMI	18.9 (2.5)/19.5 (2)	29.9 (2.6)/22.2 (4.9)	17.2 (1.2)/19.7 (3.2)
Overweight, %	4.5/0	14.3/23.8	0/20
PA**	4.7 (0.6)/4.7 (0.5)	4.4 (0.7)/4.1 (0.7)	3.7 (0.6)/4 (0.7)
Unfit (low fitness), %	0/0	7.1/19	0/20
19 years of age			
Age	18.8 (0.4)	18.8 (0.4)	18.8 (0.4)
Height, cm	184.5 (6.7)/166.1 (5.6)*	180.8 (8.3)/167.1 (6.2)*	172.8 (7)/166.9 (6.3)
Weight, kg	77.7 (13.6)/62.5 (8)*	78.1 (12.1)/66.8 (15.1)*	56.4 (9.8)/62.3 (13.6)
BMI	22.8 (4)/22.6 (2.5)	23.9 (4.2)/23.8 (4.9)	18.7 (1.7)/22.1 (3.3)
Overweight, %	18.2/18.2	42.9/28.8	0/20
PA**	4.2 (0.8)/4.1 (0.8)	3.8 (0.8)/3.9 (0.9)	2.6 (0.6)/2.6 (1.1)
Unfit (low fitness), %	0/0	14.3/19	0/0

Note. BMI = body mass index; PA = physical activity. PA: 1 = never, 2 = less than once a week, 3 = once a week, 4 = 2 to 3 days a week, 5 = most days of the week.

*Significant differences between sexes, $p < .05$.

**Significant differences among the three groups (organized sport, unorganized PA, and no weekly PA), $p < .05$.

The characteristics of the participants categorized into the three groups are presented in Table 3. The table shows that the participants in the three groups differed in several ways. Statistical analyses revealed that the PA level was significantly different in the three groups (organized sport, unorganized PA, and no weekly PA) both at 14 years of age ($X^2 = 7.9$, $p < .05$) and at 19 years of age ($X^2 = 13.8$, $p < .05$). There were no other differences related to group participation in the other variables included in Table 3 ($p > .05$). A follow-up test showed that at 14 years of age, adolescents in the organized sport group exhibited a statistically significant higher activity level than adolescents in the “no weekly PA” group ($Z = -2.6$, $p < .05$). At 19 years of age, both adolescents in the organized sport group and those the unorganized PA group reported a higher PA level than that of adolescents in the “no weekly PA” group ($Z = -3.5$, $p < .05$, and $Z = -3.1$, $p < .05$, respectively). Further statistical analyses showed a significant difference between sexes according to height and weight at 19 years of age among adolescents who participated in organized sport ($t = -5.6$, $p < .05$, and $t = -2.3$, $p < .05$, respectively) and among adolescents who participated in unorganized PA ($t = -7.8$, $p < .05$, and $t = -3.4$, $p < .05$, respectively). There were no other sex differences in the other variables included in Table 3 ($p > .05$). The development of VO_{2peak} ($mL \cdot min^{-1} \cdot kg^{-1}$) in the three groups is presented in Figure 1.

A two-way ANOVA revealed a statistically significant difference in VO_{2peak} ($mL \cdot min^{-1} \cdot kg^{-1}$) among the three groups in Figure 1 (organized sport, unorganized PA, and no weekly PA) at 14 years of age, $F(2, 73) = 7.16$, $p < .05$,

$\eta^2 = .170$. There was also a statistically significant main effect of sex on VO_{2peak} , $F(2, 73) = 27.56$, $p < .05$, $\eta^2 = .282$. However, no statistically significant interaction was found between sex and group categorization, $F(2, 73) = 0.05$, $p > .05$, $\eta^2 = .02$. Post-hoc tests with Bonferroni corrections showed that at 14 years of age, adolescents participating in organized sport had a statistically significantly higher VO_{2peak} than that of adolescents participating in unorganized PA (mean difference = $8.46 mL \cdot min^{-1} \cdot kg^{-1}$, 95% CI [4.6, 12.3], $p < .05$) and adolescents with no weekly PA (mean difference = $6.44 mL \cdot min^{-1} \cdot kg^{-1}$, 95% CI [0.2, 12.7], $p < .05$), respectively. However, there were no statistically significant differences in VO_{2peak} between adolescents participating in unorganized PA and adolescents with no weekly PA at 14 years of age (mean difference = $-2.0 mL \cdot min^{-1} \cdot kg^{-1}$, 95% CI [-8.2, 12.2], $p > .05$).

A two-way ANOVA also showed a statistically significant difference in VO_{2peak} ($mL \cdot min^{-1} \cdot kg^{-1}$) among the three groups in Figure 1 at 19 years of age, $F(2, 73) = 14.00$, $p < .05$, $\eta^2 = .300$, and a statistically significant main effect of sex on VO_{2peak} at 19 years of age, $F(2, 73) = 36.49$, $p < .05$, $\eta^2 = .343$. However, no statistically significant interaction was found between sex and group categorization at 19 years of age, $F(2, 73) = 0.05$, $p > .05$, $\eta^2 = .00$. Post-hoc tests with Bonferroni corrections revealed that at 19 years of age, adolescents participating in organized sport exhibited a statistically significantly higher VO_{2peak} than that of adolescents participating in unorganized PA (mean difference = $10.14 mL \cdot min^{-1} \cdot kg^{-1}$, 95% CI [6.9,

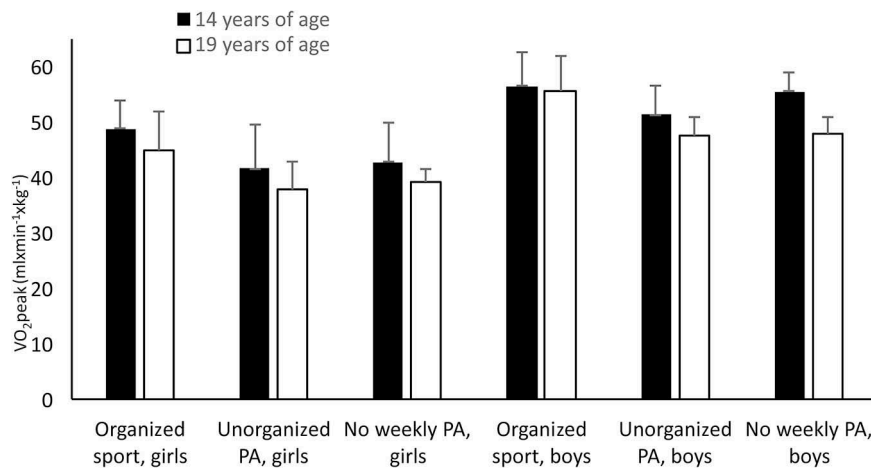


Figure 1. Peak oxygen consumption (VO₂peak; mL·min⁻¹·kg⁻¹) among girls and boys in organized physical activity (PA), unorganized PA, and no weekly PA at 14 and 19 years of age.

13.4], $p < .05$), and adolescents with no weekly PA (mean difference = 9.53 mL·min⁻¹·kg⁻¹, 95% CI [4.2, 14.8], $p < .05$), respectively. However, there were no statistically significant differences in VO₂peak between adolescents participating in unorganized PA and adolescents with no weekly PA at 19 years of age (mean difference = -0.6 mL·min⁻¹·kg⁻¹, 95% CI [-4.9, 5.7], $p > .05$). The intercept in a univariate ANOVA showed that VO₂peak (mL·min⁻¹·kg⁻¹) decreased significantly among the three groups from 14 to 19 years of age, $F(1, 73) = 21.74$, $p < .05$. However, no statistically significant difference was identified in the development of VO₂peak (mL·min⁻¹·kg⁻¹) among the three groups from 14 to 19 years of age, $F(2, 73) = 1.44$, $p > .05$.

Discussion

In the present study, we found that adolescents who participated in organized sport achieved and maintained a higher level of CRF compared with adolescents who participated in unorganized PA and adolescents with no weekly PA. As shown in Figure 1, this was the case for both girls and boys at 14 and 19 years of age, indicating the impact of organized sport was stable across sex and age.

Boys and girls in the present study increased their VO₂peak (L·min⁻¹) from 14 to 19 years of age. However, when controlling for body mass, was, VO₂peak (mL·min⁻¹·kg⁻¹) decreased. Naturally, changes in weight had a major impact on the development of VO₂peak. Table 1 shows an increase in weight and BMI, resulting in twice as many adolescents being categorized as overweight during the 5-year study period. These findings—increasing VO₂peak and weight and decreasing absolute VO₂peak—correspond with those of previous studies on adolescents (Armstrong et al., 2011; Kemper et al., 2013).

In accordance with extant literature, the level of PA decreased with increasing age (Bélanger et al., 2009; Kollé et al., 2012; Riddoch et al., 2004; Telama & Yang, 2000). Table 1 and Table 3 show that the decrease in PA from 14 years of age to 19 years of age applied to both boys and girls and occurred in all three groups (organized sport, unorganized PA, and no weekly PA). However, PA levels among adolescents taking part in organized sport were significantly higher compared with adolescents with no weekly PA.

The results showed no statistically significant difference in the development of VO₂peak (mL·min⁻¹·kg⁻¹) among the three groups (Figure 1). It may be argued that it is easier to maintain VO₂peak level during the period under examination if the level is already low at 14 years of age. This argument could help explain why there was no change in VO₂peak level in the group of adolescents who participated in both organized sport and unorganized PA at 14 years of age, and then no longer participated in weekly PA at 19 years of age. This phenomenon may also explain why the (smaller) decrease in VO₂peak level among the adolescents who participated in organized sport did not differ from the decrease in the other groups in Figure 1.

The present study highlights the benefit of participation in organized sport, as suggested in previous research (Aarnio et al., 2002; Kjønnesen et al., 2009; Santos et al., 2005; Telama et al., 2006). The obvious advice is for adolescents to maintain their participation in organized sport to obtain the benefits of improved CRF. However, the dynamics of organized sport and such intentions do not appear to coincide. Even though Norway is characterized by particularly high levels of participation in organized sport among children and youth, there is a corresponding high dropout rate during adolescence (Green, Thurston, Vaage, & Roberts,

2015; Seippel, 2017; Stöckel et al., 2010). Further calculations based on Table 2 showed that 29 participants (38.16%) experienced dropping out from organized sport from 14 to 19 years of age. It is also important to note that the group of adolescents who participated in organized sport at both times included a majority of boys (22 boys, 11 girls), whereas the group of adolescents involved in unorganized PA at 19 years of age included a majority of girls (14 boys, 20 girls). These numbers are in agreement with how larger studies have described the dynamics of organized sport in Norway with girls dropping out at an earlier age and at a faster rate compared with boys (Stöckel et al., 2010).

The obvious explanation for the positive relationship between a high level of CRF and participation in organized sport lies in the increasing demands for effort and intensity with increasing age (Armstrong et al., 2011; Kemper et al., 2013). This development is also an aspect of specialization in organized sport, involving an increased number of practices in one sport and an accompanying increase in effort, intensity, and seriousness. The specialization and seriousness of sport can have a negative effect on participation levels. In fact, previous research revealed that one of the most important reasons given by children and adolescents for dropping out is that a particular sport “isn’t fun any longer” (Crane & Temple, 2015; Temple & Crane, 2016).

Understanding that the development of organized sport with increasing age plays a major role in adolescents’ decisions to withdraw from sport should be accompanied by the knowledge that dropping out does not lead to inactivity. The results of the present study are in accordance with those of the extant literature, revealing that adolescents chose other types of PA in which to be physically active (Green, Thurston, & Vaage, 2015; Lewis, Dollman, & Dale, 2007; Seippel, 2017). However, the findings of the present study identified a strong relationship between adolescent participation in organized sport and CRF, and are consistent with the findings of previous research (Khan et al., 2012; Kjønnsen et al., 2009; Perkins et al., 2004; Telama et al., 2005).

There are several strengths and limitations of this study. One strength of the study is that it was based on a longitudinal design among the same participants using the same questions and test every year, performed in the same room, with identical test procedures, the same test equipment, and the same test leader at all of the six test measures. Furthermore, many of the variables, such as VO_2 peak, overweight, and sex, were based on high-quality standard procedures. Several limitations also exist in this study.

Level of PA was self-reported and measured with only one question in the questionnaire. Objective measures by accelerometers would have been preferable. The number of participants was also somewhat low, and there were some dropouts. Statistical analyses also showed that the 76 participants included in the study had a higher absolute VO_2 peak than the 40 dropout students at 14 years of age. However, there were no statistically significant differences in absolute VO_2 peak and development of absolute VO_2 peak between the 76 participants included in the analysis and the 12 dropout students with valid absolute VO_2 peak measures at 19 years of age.

Conclusion

The cardiovascular health benefits of PA and CRF have been well established. Numerous studies in several countries have also documented the decline in general PA and participation in organized sport with increasing age (Bélanger et al., 2009; Kolle et al., 2012; Riddoch et al., 2004; Telama & Yang, 2000). Although several studies have indicated that participation in organized sport seems to be of particular importance for adolescents’ CRF (Aires et al., 2012; Pfeiffer et al., 2007), no extant literature has yet investigated how regular participation in organized and unorganized PA during lower secondary school and high school affects the development of VO_2 peak among adolescents. The main finding of this study was that adolescents who participated in organized sport preserved their CRF better compared with adolescents who participated in unorganized PA and adolescents with no weekly PA. There were no statistically significant differences in VO_2 peak values between adolescents participating in unorganized PA and adolescents with no weekly PA. The VO_2 peak values of the groups at 14 and 19 years of age indicated that participation in organized sport was critically important to the achievement and maintenance of a high VO_2 peak.

What does this article add?

The findings of the present study highlight the benefits of adolescents’ participation in organized sport in the achievement and maintenance of high levels of CRF. Based on the fact that almost all Norwegian children and youth participate in organized sport at one time or another (Green, Thurston, & Vaage, 2015; Stöckel et al., 2010), the obvious advice would be for them to continue participating in organized sport for as long as possible. However, because the dynamics of organized sport and such intentions do not appear to coincide, such advice

should be accompanied by suggestions regarding how organized sport can optimally adapt. Acknowledging that this advice would be outside the framework of this article, we simply conclude that participation in organized sport has the benefit of improved CRF, which was not found in unorganized PA.

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