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Training Volume and Intensity of Physical Activity among Young Athletes: The Health Promoting Sports Club (HPSC) Study

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Abstract

Both training volume and overall physical activity (PA) play a role in young athletes' sports performance and athletic development. The purpose of this study was to describe the training volume and PA of young athletes in endurance, aesthetics, ball games, and power sports. Questionnaire data (n = 671) were obtained from 15-year-old Finnish athletes on sports participation, along with accelerometer data (n = 350) assessing the amount and intensity of their PA. The athletes' mean weekly training volume was 11 h 41 min. Objectively assessed PA amounted to 4 h 31 min daily, out of which 1 h 31 min was at a level of moderate-to-vigorous intensity (MVPA). Among 24% of the athletes, the weekly training volume (in hours) exceeded the recommended level of age-in-years, which might increase their risk of sports injuries. At the same time, one in six athletes (16%) did not—on average—reach the internationally recommended threshold level of at least 60 minutes of MVPA per day. Compared to girls, boys averaged 2.5 more hours of training per week, and had 21 more minutes of MVPA per day. Moreover, boys had a higher goal orientation than girls, with 52% of the boys and only 29% of the girls focused

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on success at adult level. Although total training volume and PA did not differ among sports types, there were differences in training forms, and in the proportions of MVPA. The young athletes were found to vary greatly in training forms, training volumes, MVPA, and goal orientation; hence, training should be planned individually, both for team sports and individual sports.

Keywords

Adolescents, Athlete, Physical Activity, Sports, Training Volume

1. Introduction

There is a continuous debate on the optimal elements for athletes' development, but most studies agree that training has an essential role in becoming an elite-level athlete (Baker & Young, 2014; Rees et al., 2016; Tucker & Collins, 2012). Ericsson, Krampe, & Tesch-Römer (1993) proposed that athletes who aim at elite proficiency should accumulate 10,000 hours of deliberate practice over about 10 years. Deliberate practice refers to structured physical activity (PA), with the primary goal of improving one's current sports performance (Ericsson et al., 1993). Subsequent studies have demonstrated that there is considerable variation in the amounts of training conducted by elite athletes. For instance, regarding their trajectory to the elite level, gymnasts and triathletes reported over 10,000 hours of deliberate practice, whereas ice-hockey players accummulated less than 4000 hours of such practice (research summary from Baker & Young, 2014).

There are also differing views on age-appropriate training volume and on adolescents' readiness to start more rigorous training (Fraser-Thomas, Côté, & Deakin, 2008). One important aspect has been the prevention of sports injuries, especially those resulting from over-use. Young athletes undergoing high amounts of organized training report more injuries than those who train less (Jayanthi, LaBella, Fischer, Pasulka, & Dugas, 2015; Mattila, Parkkari, Koivusilta, Kannus, & Rimpelä, 2009). With this in mind, Jayanthi et al. (2015) recommend that young athletes should keep their average weekly training volume, measured in hours, no higher than their age in years (this being taken to represent their age-appropriate training volume).

Relatively little research has been conducted on training volume among young athletes in Finland and other western countries. One previous study (Aarresola & Konttinen, 2012a, 2012b) reported the training hours of Finnish athletes aged 14 - 15, while another (Blomqvist, Mononen, Koski, & Kokko, 2019) reported weekly coach-led training sessions and self-directed training sessions among Finnish young people aged 9 - 15 (sport unspecified). Some studies have made no distinction between organized training and hours of actual competition (Moseid, Myklebust, Fagerland, Clarsen, & Bahr, 2018; Jayanthi et al., 2015),

while others have collected training hours retrospectively memorizing yearly hours of childhood practice, competition and play (Ford et al., 2012).

The training profiles of many elite athletes go beyond pure training, to include also playful activities. These can encompass both free play and deliberate play, i.e. PA that is intrisically motivating, providing immediate gratification, and designed to maximize enjoyment (Côté, Baker, & Abernethy, 2007; Rees et al., 2016). The overall PA can involve different combinations of e.g. active travel, free play, and either organized or self-directed training in one or several sports. Despite this, the PA of athletes is seldom specified beyond their main sports practices, though attention has been drawn to the increased risk of injury among athletes whose ratio of organized sports to free play exceeds 2:1 hours/week (Jayanthi et al., 2015).

Among adolescents, it makes little sense to restrict the perspective only to elite-level training. In Finland, 88% of persons aged 9 - 15 have participated in sports club activities at some point in their childhood, while 62% are participating currently (Blomqvist et al., 2019). The broad participation of children and adolescents in sports clubs implies considerable heterogeneity in the fitness and health of those who attend. Thus, sports clubs do not merely promote a prospective elite; they also have an impact on public health insofar as they offer PA for a large proportion of young people, including children and adolescents with no aspirations towards a career in sport. However, there is at present a lack of information on the goal orientations of young athletes—here using the term "athletes" to encompass persons who are active in sport, whether or not they view themselves as on a path towards an elite level. Overall, relatively few studies have objectively measured the PA intensities of young athletes (Fenton, Duda, & Barrett, 2016; Marques, Ekelund, & Sardinha, 2017), especially with regard to a wide range of sports. It is worth noting that PA insufficiencies (in relation to the WHO daily PA guidelines for health (World Health Organization, 2010) have been found among young athletes (Fenton et al., 2016; Kokko et al., 2018; Marques et al., 2017) as well as among young people more generally (Kokko et al., 2015; Aubert et al., 2018).

To obtain more detailed information, the present study examined 15-year-old Finnish athletes participating in a range of sports. We sought to determine their training volume (via a survey, n = 671), plus the amount and intensity of their PA (via an objective measure, n = 350). We also examined how gender, current competition level, and future goal orientation were associated with the training volume.

2. Methods

2.1. The Sample and Data Collection

The study reported here formed part of the Health Promoting Sports Club (HPSC) study conducted in Finland by the University of Jyväskylä, and by six Sports & Exercise Medicine Centres plus the UKK institute (Kokko et al., 2015).

The study sample consisted of 15-year-old members of sports clubs (hereafter referred as athletes' to encompass persons who are active in sport), participating in ten of the most popular sports in Finland (basketball, cross-country skiing, floorball, soccer, gymnastics, ice hockey, orienteering, skating, swimming, and track and field). Sampling was carried out using a probability-proportional-to-size (PPS) method, applying regional stratification and clustering. The sports club was taken as the primary sampling unit. Within each sports club one team or training group was sampled using simple random sampling (SRS). All the members of a given team/group were invited to take part. The clubs contacted were dispersed in six different areas, in proximity to Centres of Excellence in Sports and Exercise Medicine. These were located in the six largest Finnish cities or their surrounding municipalities, within different parts of Finland. The data were collected in the middle of the main competition season, i.e. from January to May 2013 for winter sports, and from August to December 2013 for summer sports. Complementary data on young athletes were collected from January to May 2014.

In total, 1889 athletes were invited to complete an internet-based questionnaire, and 759 (40%) responded. The data in this article were based on responses by 671 athletes (girls = 288, boys = 383) to questions concerning their training and PA (the questions are described in detail in the Measurements section). The study applied data only from those who had given permission to use their responses as research data.

The PA levels of a smaller (a randomly selected, based on power calculations, invited to pre-participation screening, see Kokko et al., 2015) sample of the young athletes were objectively measured by the Hookie accelerometer (AM20 Activity Meter, Hookie Technologies Ltd., Helsinki, Finland), which has been shown to be a valid measurement tool among young people (Aittasalo et al., 2015). The accelerometer collected and stored tri-axial data (in raw mode) in actual g-units. The data were analysed in units of 6 seconds' duration.

In total, 424 sports club participants (209 boys, 215 girls; 38% of those invited) took part in the pre-participation screening. During their first visit, the accelerometer was fitted, with guidance given for use over seven consecutive days (i.e. that it should be worn during waking hours, except when bathing or during water activities; for further information see (Kokko et al., 2015). Swimmers (n = 36) were excluded from the analysis, as they were unable to use the accelerometer during their swimming training. Once written consent had been received, valid accelerometer data (covering at least four days, used for at least 10 hours each day) were available from 350 athletes (173 boys, 178 girls).

2.2. Measurements

Questionnaire data:

Type of sport: Athletes were categorized according to their sport type, as described by Sundgot-Borgen & Larsen (1993) and modified by Diehl, Thiel, Zipfel, Mayer, & Schneider (2014). The categories were: 1) *endurance sports*

(cross-country skiing, orienteering, long-distance runners, swimming; n = 127); 2) *aesthetic sports* (gymnastics, skating; n = 95); 3) *ball games* (basketball, floorball, ice-hockey, soccer; n = 388); and 4) *power sports* (track & field, without long-distance runners; n = 50). There were only a few weight-dependent and technical sports participants (n = 11); hence these were excluded, when the results were analysed by the *type of sport*.

Competition level: Responses to the question on the level at which the athletes were competing were categorized into three groups: 1) *recreational*; 2) *regional*; and 3) *national* level. The recreational group included respondents who reported participation in no competitions at all. For analytical reasons, the respondents were subsequently dichotomized into 1) national level and 2) regional/recreational level.

Goal orientation was estimated via the following question: "What is your goal as an athlete?" The structured response options encompassed three groups; 1) no competition-based goals; 2) a focus on success in adolescence; and 3) a focus on success at adult level.

The *training volume* of the athletes' main sport was estimated via questions on the frequency per week of participants' 1) coach-led training, 2) self-directed training. There was also a question on the typical duration of these sessions. Games or competitions were calculated via the weekly frequency of competition events in main sports, applying an estimated duration of 1 h 30 min per single event. In addition, estimation was made of training and games that did not pertain to the participant's main sport.

Total training volume was estimated by summing the coach-led training, self-directed training, plus games/competitions for the main sport, together with the training and competition/games volume of pursuits other than the main sport. The respondents were further dichotomized according to their training volume level: 1) less than 15 hours, and 2) 15 hours or more.

The *age-appropriate training volume* calculation (see Jayanthi et al., 2015) was conducted according to the proportion of athletes who exceeded 15 hours of total training volume in a week—in other words, the percentage of participants whose training hours exceeded the mean age of the athletes in years.

Free play: Participation in free play was estimated via the question "Apart from events in your main sport, how often per week do you do exercise or take part in self-directed sport in your free time (activity lasting at least half an hour, and sufficient to break sweat, e.g. while playing with friends)?" This variable was calculated by estimating each event at one hour in duration, and summing the hours.

Active travel to school was estimated via the question "How long per day do you regularly spend on active travel (by walking/cycling/other physical activity) to and from school?" The options were: 1) None; 2) Less than 20 minutes; 3) 20 - 39 minutes; 4) 40 - 59 minutes; 5) One hour or more.

Active travel to training was estimated via the question "How much time per day do you regularly spend on active travel (by walking/cycling/other physical

activity) to and from training?" The options were: 1) None; 2) Less than 20 minutes; 3) 20 - 39 minutes; 4) 40 - 59 minutes; 5) One hour or more.

Accelerometer data

Intensity: PA was classified into three intensity categories, based on metabolic equivalents (MET), labelled *light, moderate,* or *vigorous*. Light PA was defined as activity corresponding to 1.5 - 2.9 MET, moderate activity as 3.0 - 5.9 MET, and vigorous activity as 6 MET and over (Vähä-Ypyä et al., 2015).

Type of sport was categorized as follows: endurance: $n = 76$, aesthetic: $n = 71$, ball games: $n = 160$, power sports: $n = 42$, with swimmers excluded due to a lack of accelerometer data, as indicated previously. Due to the small number of participants in weight-dependent ($n = 0$) and technical sports ($n = 1$), these too were excluded when comparisons between sports types were conducted.

Average threshold of at least 60 *minutes of MVPA per day* was transformed to a dichotomous variable according to the values obtained for the measurement period. The threshold was considered to be reached if, over the measurement period of 4 - 7 days of valid PA data, the average daily MVPA was at least one hour.

2.3. Data Analysis

The significance levels of the pairwise associations between the categorical variables were analysed via cross-tabulation and the Chi-square test. Group differences between PA and genders were analysed using unpaired *t*-tests, and between sports types via analyses of variance (ANOVA). The ANOVA results were confirmed with non-parametric tests, due to the relatively small numbers of cases in some groups.

The associations of training volume and overall PA with competitional level and goal orientation were analysed using multivariable logistic regression analyses. The results are presented with odds ratios (OR), along with their 95% confidence intervals (CI). Data analysis was performed using SPSS version 24. The significance level was taken as $p < 0.05$ in all the statistical tests.

2.4. Ethical Issues

The study was carried out in conformity with the Declaration of Helsinki. Ethical approval was granted for the study by the Committee of Health Care, District of Central Finland (record number: 23U/2012). For the questionnaire data, written consent was required from the young people participating. For the pre-participation screening, written consent was required from a guardian and from the adolescent him/herself (Kokko et al., 2015). All respondents were notified that they had the option to refuse to participate, and to withdraw from the study at any time.

3. Results

3.1. Participant Characteristics

The majority (59%) of the young athletes who responded to the survey (32% of

the girls, 78% of the boys) participated in ball games, while 19% (26% of the girls, 14% of the boys) participated in endurance sports. Fourteen percent of the athletes took part in aesthetic sports (31% of the girls, 2% of the boys), and eight percent in power sports (11% of girls, 6% of boys).

Totally, 65% of athletes were competing at national level, 32% at regional level, and three percent at recreational level (see Table 1). The competition level was highest in endurance sports, in which 86% of the athletes reported competing at national level. The largest proportion of athletes who were not competing at all was found in aesthetics (14% of the girls and 33% of the boys).

Half (52%) of the boys reported that they focused on success at adult level, while the proportion among the girls was 29%, ($p < 0.001$). One-fifth (20%) of the athletes had no goal orientation at all. The goal orientation varied considerably between different sports (Table 1). The smallest proportion of athletes aiming at adult level in their sport was among the girls in aesthetics (16%) and ball games (24%). Conversely, the largest proportion heading towards adult level was among the boys in aesthetics (67%), and power sports (64%).

3.2. Training Volume

The athletes' mean total weekly training volume was 11 hours 41 minutes, with boys training more than girls (boys 12 h 33 min, girls 10 h 33 min; see Table 2). The weekly mean volume for coach-led training was approximately seven hours,

Table 1. Percentages of training and PA-related factors among young athletes; by sport type and gender.

	Endurance girls	Endurance boys	Aesthetic girls	Aesthetic boys	Ball games girls	Ball games boys	Power sports girls	Power sports boys	Girls	Boys	Total
Goal orientation											
No orientation	15	16	20	33	32	19	20	13	23	19	20
Junior level	40	32	64	0.0	45	30	40	23	49	29	38
Adult level	45	52	16	67	24	51	40	64	29	52	42
Competition level											
Recreational	4	2	14	33	1	0	3	0	6	1	3
Regional	16	28	15	0.0	46	39	33	23	27	36	32
National	80	70	71	67	53	61	63	77	67	63	65
Training volume											
0 - 4.9 hours	11	7	11	33	4	3	0	9	8	4	6
5.0 - 9.9 hours	37	28	40	17	51	31	39	9	42	29	35
10 - 14.9 hours	27	35	29	17	35	38	46	55	33	39	36
15 - 19.9 hours	18	20	11	0	7	20	14	27	12	20	16
>20 hours	7	9	8	33	3	9	0	0	5	9	7
Age-appropriate training volume ratio[†]	25	30	19	33	9	28	14	27	17	29	24

[†]proportion (%) of those exceeding 15 hours of training in a week.

Table 2. Mean hours of weekly training and PA; by gender and sport type with *p*-values.

	Total (n = 660)	Girls (n = 282)	Boys (n = 378)	p	Endurance (1)	Aesthetic (2)	Ball games (3)	Power sports (4)	p
Coach-led training	7:09	6:50	7:23	0.100	5:25	8:48	7:17	7:42	1 < 2 - 4, 2 > 1, 3, †
Self-directed training	1:55	1:44	2:02	0.091	3:28	1:05	1:37	1:40	1 > 2 - 4, ‡
Games/competitions	1:38	1:04	2:04	<0.001	1:35	0:13	2:07	1:03	2 < 1, 3 - 4, 3 > 1 - 2, 4, §
Other than main sports	0:59	0:55	1:03	0.222	1:10	0:38	0:57	1:20	2 < 4, ¶
Total training volume	11:41	10:33	12:33	<0.001	11:38	10:44	11:58	11:45	
Free play	1:41	1:34	1:47	0.087	1:41	1:18	1:48	1:37	2 < 3, ‖
Active travel (school)	3:00	3:07	2:56	0.045	3:13	3:06	2:56	2:45	
Active travel (training)	1:52	1:58	1:48	0.238	1:43	2:14	1:50	1:56	

†: 1 < 2 - 3, <0.001, 1 < 4, 0.016; 2 > 3, 0.022; ‡: 1 > 2 - 4, <0.001; §: 2 < 1, 3 - 4, <0.001; 3 > 1 - 2, 4, <0.001; ¶: 2 < 4, 0.045; ‖: 2 < 3, 0.033.

and for self-directed training approximately two hours (Table 2). The mean weekly volume for non-main-sport training was one hour. Boys participated in games or competitions for two hours per week, while girls participated for one hour per week.

More than one third of the athletes (35%) trained for 5 - 9.9 hours per week, while almost the same proportion (36%) trained for 10 - 14.9 hours per week (Table 1). Seven percent of the athletes exceeded a weekly total of 20 hours of training, while 6% trained for less than five hours per week.

The proportion of athletes exceeding the age-appropriate training amount (training volume over 15 hours) was 24%. The percentage was higher among boys (29%) than among girls (17%) ($p < 0.001$) (Table 1).

Among boys, the age-appropriate training volume proportions were similar between different sports types (27% - 33%). The differences were greater among girls (e.g. 25% in endurance sports versus 9% in ball games).

Differences between sports types

There was no difference in total training volume between sports types (Table 2). However, endurance athletes reported less coach-led training and more self-directed training than other athlete groups. Endurance athletes underwent coach-led training for 5.5 hours per week, and training alone for 3.5 hours per week. The corresponding weekly amounts for the other athletes were 7 - 9 hours of coach-led training, and less than 2 hours of self-directed training.

Games/competitions were common weekly events in ball games (2 hours per week), whereas competitions took place less frequently in aesthetic sports (13 min per week). In addition, aesthetic athletes rarely participated in other than their main sport training sessions (38 min per week). Multiple participation was more common among power sport athletes (one hour 20 min).

Gender differences within sports types

Training volumes did not differ between genders among aesthetic and power sport athletes, though only a small number of boys participated in aesthetics

(Table 3). Among athletes in ball games, boys trained in total more than girls (boys 12.5 hours, girls 10 hours; see Table 3). This difference was seen in coach-led and self-directed training and games, but not in non-main-sport training. Among endurance athletes, boys took part in competitions more than girls (boys 2 hours per week, girls less than 1.5 hours per week).

3.3. Free Play and Active Travel

The weekly mean time for free play was roughly the same among boys (1 h 47 min) and girls (1 h 34 min; see Table 2). Ball games participants had more free play than aesthetic participants, but otherwise there were no differences in weekly free play volume between sports types (Table 3).

Active travel to school occupied 3 hours per week, while travel to training occupied 2 hours per week (Table 2). Girls were more physically active in going to school and returning home than boys (girls 3 hours 7 min, boys 2 hours 56 min). Within sports types, there were no inter-gender differences in mean active travel amounts (Table 3).

3.4. Training Volume and Associations with Background Variables

Athletes competing at national level were more likely to achieve 15 hours or more training (OR 5.3) compared to athletes who competed at regional or recreational level (Table 4).

Goal orientation was similarly associated with training volume. Those athletes who focused on success at adult level were more likely to undergo 15 hours or more training (OR 3.6) compared to those athletes who had no goal orientation. Boys were more likely to indicate non-age-appropriate amounts of training (OR 2.1) than girls.

3.5. Intensity of Physical Activity

As measured by the accelerometer, daily PA was on average 4 hours 31 minutes

Table 3. Mean hours of weekly training and PA within different sports types; by gender, with *p*-values.

	Endurance			Aesthetic			Ball games			Power sports		
	Girls (n = 73)	Boys (n = 54)	p	Girls (n = 89)	Boys (n = 6)	p	*Girls* (n = 92)	*Boys* (n = 296)	p	*Girls* (n = 28)	*Boys* (n = 22)	p
Coach-led training	5:40	5:05	0.557	8:34	12:05	0.460	6:06	7:39	<0.001	7:06	8:25	0.149
Self-directed training	3:08	3:56	0.156	1:03	1:38	0.338	1:13	1:44	0.020	1:52	1:25	0.212
Games/competitions	1:21	1:58	0.001	0:12	0:15	0.828	1:46	2:13	<0.001	1:01	1:05	0.757
Other than main sport	1:05	1:16	0.480	0:40	0:35	0.507	0:55	0:58	0.759	1:05	1:39	0.261
Total training volume	11:14	12:15	0.289	10:29	14:33	0.433	10:00	12:33	<0.001	11:04	12:36	0.193
Free play	1:39	1:52	0.254	1:20	0:49	0.452	1:51	1:47	0.735	1:28	1:48	0.466
Active travel (school)	3:20	3:03	0.168	3:09	2:13	0.078	1:58	2:55	0.713	2:40	2:50	0.697
Active travel (training)	1:37	1:49	0.575	2:12	1:23	0.830	1:59	1:47	0.279	1:57	1:52	0.838

Table 4. Logistic regression analysis: factors associated with training volume.

	Training volume	
	n (%)	OR (95% CI)
Gender	671	
Girl	288 (43)	1
Boy	383 (57)	2.1 (1.4 - 3.2)**
Goal orientation	670	
No orientation	136 (20)	1
Junior level	253 (38)	1.7 (0.8 - 3.6)
Adult level	282 (42)	3.6 (1.8 - 7.3)***
Competition level	671	
Regional /recreational	231 (35)	1
National	424 (65)	5.3 (3.0 - 9.3)***

<0.01; *<0.001.

for the athletes, with the boys more active than the girls (boys 4 hours 40 min, girls 4 hours 22 min; see Table 5). There was no difference between genders in light PA. However, boys were more active than girls in moderate and vigorous intensity levels. Considering the athletes as a whole, the daily MVPA averaged 1 hour 31 minutes (boys 1 hour 42 min, girls 1 hour 21 min).

Comparisons between sports types revealed differences in mean daily hours of moderate and vigorous intensity PA (Table 5). Aesthetic athletes accumulated less MVPA (1 hour 18 min) than athletes in endurance (1 hour 32 min) and ball games (1 hour 39 min). Power sport athletes accumulated less MVPA (1 hour 24 min) than athletes in ball games (1 hour 39 min). Total daily PA and light PA did not show significant differences between sports types.

In total, 84% of the athletes reached the average threshold level of at least 60 minutes of MVPA per day. Boys reached the threshold more commonly than girls (boys 90%, girls 79%), while athletes in ball games (90%) reached this level more commonly than athletes in other sports types (endurance 84%, aesthetic 76%, power sports 79%).

4. Discussion

This represents the first large-scale study on Finnish 15-year-old athletes, covering the training volume and intensity of their PA, and representing a broad range of sports. Training volume and PA are typically observed separately, making this study novel as combining the two in the analysis. We found that the young athletes' mean training volume was approximately 12 hours per week. They accumulated on average 4.5 hours of objectively assessed PA daily, with 1.5 hours of this involving moderate-to-vigorous intensity. In total, 84% of the athletes reached the average threshold level of at least 60 minutes of MVPA per day. The training volume and PA intensity were higher among boys than among

Table 5. Mean values (hours and minutes/day) of differing-intensity PA; plus prevalence of reaching an average threshold of at least 60 minutes of MVPA per day among boys and girls, and per sport type.

Intensity of the PA	Total (n = 350)	Girls (n = 177)	Boys (n = 173)	p	Endurance (1) (n = 76)	Aesthetic (2) (n = 71)	Ball games (3) (n = 160)	Power sports (4) (n = 42)	p
Light	3:00	3:02	2:58	0.386	2:55	3:07	2:59	2:57	
Moderate	1:15	1:06	1:24	<0.001	1:11	1:09	1:20	1:10	2 < 3, 0.013
Vigorous	0:17	0:14	0:18	0.008	0:20	0:09	0:18	0:14	2 < 1, 3, <0.001
MVPA	1:31	1:21	1:42	<0.001	1:32	1:18	1:39	1:24	2 < 1, 0.047 2 < 3, <0.001 3 > 4, 0.039
Total PA	4:31	4:22	4:40	0.005	4:27	4:25	4:38	4:21	
≥60 min MVPA	84%	79%	90%	0.007	84%	76%	90%	79%	0.033

girls. Compared to girls, boys averaged 2.5 more hours of training per week, and 21 more minutes of MVPA per day. Although total training volume and PA did not differ between sports, there were differences in training forms (involving coach-led training and competition volumes), and also differences in MVPA.

The differences found in training forms reflect the specific nature of different sport types. Aesthetic athletes did more coach-led practice than the other athletes, and rarely took part in non-main-sport training. Among endurance athletes, self-directed training was more common than among other athletes. In line with expectations, ball-games athletes took part in games more often than other athletes. Aesthetic athletes had less moderate-to-vigorous intensity PA during an average day than the endurance and ball-games athletes. The differing requirements between sports in physical and aerobic capacity, and in technical and tactical skills, might explain the differences in training forms between sports types (Jayanthi, Pinkham, Dugas, Patrick, & LaBella, 2013).

The total training volume found in this study—comprising 12 hours weekly (under 600 hours in a year)—is broadly in line with the study of Aarresola & Konttinen (2012a, 2012b), who reported weekly training amounts of 9 to 15 hours among 14- and 15-year-old athletes in Finland, depending on the sport. Also 15-year-old soccer players have accumulated approximately 500 hours of practice and competition in a year (Ford et al., 2012). Elite-level adult athletes, too, have different amounts of training prior to competing at the top level (research summary from Baker & Young, 2014). For example, elite-level gymnastics and triathletes were found to perform over 10,000 hours of deliberate practice whereas ice-hockey players performed less than 4000 hours of practice (research summary from Baker & Young, 2014). Nevertheless, there would appear to be only limited applicability of any 10,000-hours-in-10-years "rule" (Ericsson et al., 1993) to high-performance sport (Rees et al., 2016), and one cannot lay down a specific training-volume goal for persons aiming to reach the elite level in all sports types.

Despite the above, some recommendations for adolescent's training volume have been set from the perspective of avoiding sports injuries. According to

Jayanthi et al. (2015), the weekly training volume of adolescents should be no more than their age in years. In line with a previous study (Moseid, Myklebust, Fagerland, Clarsen, & Bahr, 2018), a fairly large group (24% of young athletes) in the present study exceeded the age-appropriate training volume, and would therefore be at risk of suffering a sports injury. It should, however, be borne in mind that Jayanthi et al.'s age-appropriate training recommendation (Jayanthi et al., 2015) is merely suggestive, given that training hours can take very different forms in terms of intensity, frequency, and type (e.g. in practising strength, endurance, or flexibility, or in practising movement details).

At the present time, the level of non-organized free play is low. In our study, the athletes reported less than two hours per week of free play (i.e. in non-organized play with friends). Active travel to school and to training added on average five more hours of PA per week. Considered in total, this kind of non-organized PA is fairly limited. Especially in sports where good physical and aerobic capacity is required, non-organized PA would have possibilities to improve athletes' performance-bearing in mind also that a low ratio of free play to organized training may increase the risk of sports injury (Jayanthi et al., 2015).

Some studies have shown that two-thirds of organized training time is either light-intensity PA or sedentary (Guagliano, Rosenkranz, & Kolt, 2013; Matos & Winsley, 2007; Schlehter et al., 2017). This would suggest that organized training alone may not offer sufficient amounts of moderate-to-vigorous intensity PA for young athletes. Further studies are needed on this phenomenon. In future, there would also be a need to study the factors that tend to take time away from non-organized PA. One can speculate that activities pertaining to entertainment and social media may play a part in this.

Our findings reflect the heterogeneity of young athletes in sports club settings. While nearly 25% of the young athletes exceeded the age-appropriate training volume, 6% of the athletes had less than five hours of training per week. Moreover, one in six athletes did not, on average, reach the threshold of 60 minutes of MVPA per day. According to the international PA recommendations for health (World Health Organization, 2010), children and adolescents should engage in at least 60 minutes of MVPA *every day*, whereas new Canadian 24-Hour Movement Guidelines for Children and Youth (Tremblay et al., 2016) states "at least 60 minutes of MVPA per day *on average*". It seems that for many participants in the present study, sports training and PA overall were insufficient to reach the recommendation for health-enhancing PA. This would indicate a need to increase the training volume and/or overall PA among a substantial proportion of Finnish 15-year-old athletes. However, the type and contents of the training and of other PA would need to be carefully planned for adolescents, and in cooperation with them, in order to maintain their motivation and enjoyment, while at the same time preventing dropouts, injuries, and overtraining situations.

Overall, the young athletes in the present study spent on average 17 minutes more time in MVPA than is the case among Finnish adolescents more generally

(Husu, Jussila, Tokola, Vähä-Ypyä, & Vasankari, 2016). In a study of male Norwegian footballers (Fenton et al., 2016), the participants accumulated 17 minutes less MVPA per day than the athletes in the present study. Nevertheless, the participants in the Norwegian study were younger (mean age 11.7 years) than those in our study (aged 15), and different cut-off points were used; hence, it is difficult to draw valid comparisons.

Our athletes' goal orientations reflect the heterogeneity of young people participating in sports. Only 42% of the young athletes focused on success at adult level, while 20% of the athletes had no goal orientation. This variation in aims should be considered in the implementation of organized sports training, allowing space for "fun" as well as competitive elements in training, in efforts to keep young athletes involved in sports.

Considerably more girls than boys reported a low-level goal orientation (with only 29% of girls vs. 52% of boys focusing on success at adult level). This is in line with a previous study (Holt & Morley, 2004) and may simply reflect gender differences regarding interests. On the other hand, it may indicate more restricted possibilities for sports careers for females than for males (Holt & Morley, 2004). The gender differences were evident also in terms of training volume and PA. In line with a previous study (Marques et al., 2017), boys spent more time than girls in MVPA and in training.

Athletes who had a higher goal orientation and who competed at national level (as opposed to having a low goal orientation and participating at regional/recreational competition level) were more likely to achieve a higher training volume. It seems that orientational factors drive many athletes towards higher levels of training and exercise. In a previous study, it was found that professional football players have higher ambitions for their future career than those indicated by non-professional players, even though the non-professional players felt that they succeeded more often than the professional players (Sæther, 2017). The ambitions of athletes seem to have importance for their athletic development, but precisely how this operates would be a matter for further research.

One notable consideration is that our results are mainly based on mean values, thus overlooking individual variation. Individual differences were evident, for example, in goal orientation and competition level—as one would expect, given the wide variation in maturation, motivation, training background, skill level, etc. among young people at this age. With this in mind, arguments have been presented for more individualized training, including within team sports (Burgess & Naughton, 2010).

Methodological Considerations

The response rate to our survey was moderate (40%), which limits the representativeness of the results. On the other hand, the use of cluster sampling captured the ten most popular sports across different parts of Finland, and the loss in data was equally distributed between sports. The data is sufficiently representative of

the studied sports types in Finland with a typical response rate for questionnaires (Cook, Heath, & Thompson, 2000). It is also a strength of the accelerometer data that it were not restricted to just some limited geographical area or single sport.

The survey data were collected from a larger group of athletes (n = 671) than was the case for the accelerometer data (n = 350), and enabled gender comparisons in training volume within each sport. It should be noted that the accelerometer data represented a slightly different sample (notably excluding swimmers). The dissimilarity in the data was necessary in order to get valid data for the broadest possible range of variables.

In self-reporting surveys, there is always a possibility for misinformation. It has been reported that 24% of athletes overestimate, and 17% underestimate their training duration (Borresen & Lambert, 2006). Moreover, the young athletes in the present study reported their training volume by estimating their average training, with consequent scope for misinformation. In addition, questions on free play and competition gathered information on weekly frequency (times per week) of the events, but did not fully consider the mean duration of the events.

Having accelerometer data from subsets of athletes is a strength of this study, revealing PA of different intensities among athletes in various sports types. However, we lacked objectively measured data regarding the participants' training volumes—training which itself took different forms. New technologies have been developed to provide information on indoor and outdoor PA locations (Loveday, Sherar, Sanders, Sanderson, & Esliger, 2015), and these might help to solve the problems with self-reported data. In future research, objective measurements of this type should be tested, seeking thus to obtain more precise results on training volumes.

5. Conclusion

This study reveals the heterogeneity in 15-year-old athletes' training volumes and PA. Almost one in four athletes exceeded the age-appropriate training volume, which could increase their risk of sports injuries. Furthermore, one in six athletes did not average the threshold level of 60 minutes of MVPA per day, and this indicates insufficient PA for their health. There were also variations in the athletes' goal orientation, with boys heading towards success at adult level more often than girls.

These results give cause to bear in mind the two-fold expectations for sports clubs. It is important that training in sports club should support the development of athletes aiming at a sports career. Yet just as importantly, sports clubs should have an impact on public health, by offering opportunities for PA also to children and adolescents with less ambitious aims at their sport. This is supported by the fact that sports clubs in Finland reach more than one third of 15-year-old adolescents, and more than half of 11-year-old children (Mathisen,

Kokko, Tynjälä, Torsheim, & Wold, 2019). In addition, given the wide variation in the training forms, PA, and goal orientations among athletes—more individualistic planning in training can be argued for, both in team sports and individual sports. Moreover, previous studies have found various different training paths may lead to the elite level (research summary from Baker & Young, 2014).

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Aarresola, O., & Konttinen, N. (2012a). *Young Athlete Study: 14-15-Year-Old Team Sport Athletes' Training, Sport Paths and Microenvironment* (p. 30). Jyväskylä: Research Institute for Olympic Sports (KIHU).

Aarresola, O., & Konttinen, N. (2012b). *Young Athlete Study: 14-15-Year-Old Team Sport Athletes' Training, Sport Paths and Microenvironment* (p. 29). Jyväskylä: Research Institute for Olympic Sports (KIHU).

Aittasalo, M., Vähä-Ypyä, H., Vasankari, T., Husu, P., Jussila, A., & Sievänen, H. (2015). Mean Amplitude Deviation Calculated from Raw Acceleration Data: A Novel Method for Classifying the Intensity of Adolescents' Physical Activity Irrespective of Accelerometer Brand. *BMC Sports Science, Medicine & Rehabilitation, 7,* 18. https://doi.org/10.1186/s13102-015-0010-0

Aubert, S., Barnes, J. D., Abdeta, C., Nader, P. A., Adeniyi, A. F., Aguilar-Farias, N., Tremblay, M. S. et al. (2018). Global Matrix 3.0 Physical Activity Report Card Grades for Children and Youth: Results and Analysis from 49 Countries. *Journal of Physical Activity and Health, 15,* S215-S273.

Baker, J., & Young, B. (2014). 20 Years Later: Deliberate Practice and the Development of Expertise in Sport. *International Review of Sport and Exercise Psychology, 7,* 135-157. https://doi.org/10.1080/1750984X.2014.896024

Blomqvist, M., Mononen, K., Koski, P., & Kokko, S. (2019). Sport and Sports Club Activity. In S. Kokko, & L. Martin (Eds.), *The Physical Activity Behaviours of Children and Adolescents in Finland; Results of the LIITU Study* (pp. 49-55). Helsinki: State Sport Council Publications 1.

Borresen, J., & Lambert, M. (2006). Validity of Self-Reported Training Duration. *International Journal of Sports Science & Coaching, 1,* 353-359. https://doi.org/10.1260/174795406779367666

Burgess, D. J., & Naughton, G. A. (2010). Talent Development in Adolescent Team Sports: A Review. *International Journal of Sports Physiology and Performance, 5,* 103-116. https://doi.org/10.1123/ijspp.5.1.103

Cook, C., Health, F., & Thompson, R. L. (2000). A Meta-Analysis of Response Rates in Web- or Internet-Based Surveys. *Educational and Psychological Measurement, 60,*

821-836. https://doi.org/10.1177/00131640021970934

Côté, J., Baker, J., & Abernethy, B. (2007). Practice and Play in the Development of Sport Expertise. In *Handbook of Sport Psychology* (pp. 184-202). Hoboken, NJ: John Wiley & Sons, Inc. https://onlinelibrary.wiley.com/doi/abs/10.1002/9781118270011.ch8 https://doi.org/10.1002/9781118270011.ch8

Diehl, K., Thiel, A., Zipfel, S., Mayer, J., & Schneider, S. (2014). Substance Use among Elite Adolescent Athletes: Findings from the GOAL Study. *Scandinavian Journal of Medicine & Science in Sports, 24,* 250-258. https://doi.org/10.1111/j.1600-0838.2012.01472.x

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The Role of Deliberate Practice in the Acquisition of Expert Performance. *Psychological Review, 100,* 363-406. https://doi.org/10.1037/0033-295X.100.3.363

Fenton, S. A. M., Duda, J. L., & Barrett, T. (2016). Inter-Participant Variability in Daily Physical Activity and Sedentary Time among Male Youth Sport Footballers: Independent Associations with Indicators of Adiposity and Cardiorespiratory Fitness. *Journal of Sports Sciences, 34,* 239-251. https://doi.org/10.1080/02640414.2015.1048273

Ford, P. R., Carling, C., Garces, M., Marques, M., Miguel, C., Farrant, A., Stenling, A., Moreno, J., Le Gall, F., Holmström, S., Salmela, J. H., & Williams, M. (2012). The Developmental Activities of Elite Soccer Players Aged under-16 Years from Brazil, England, France, Ghana, Mexico, Portugal and Sweden. *Journal of Sports Sciences, 30,* 1653-1663. https://doi.org/10.1080/02640414.2012.701762

Fraser-Thomas, J., Côté, J., & Deakin, J. (2008). Understanding Dropout and Prolonged Engagement in Adolescent Competitive Sport. *Psychology of Sport & Exercise, 9,* 645-662. https://doi.org/10.1016/j.psychsport.2007.08.003

Guagliano, J. M., Rosenkranz, R. R., & Kolt, G. S. (2013). Girls' Physical Activity Levels during Organized Sports in Australia. *Medicine and Science in Sports and Exercise, 45,* 116-122. https://doi.org/10.1249/MSS.0b013e31826a0a73

Holt, N. L., & Morley, D. (2004). Gender Differences in Psychosocial Factors Associated with Athletic Success during Childhood. *The Sport Psychologist, 18,* 138-153. https://doi.org/10.1123/tsp.18.2.138

Husu, P., Jussila, A.-M., Tokola, K., Vähä-Ypyä, H., & Vasankari, T. (2016). Objectively Measured Sedentary Time and Physical Activity. In S. Kokko, & A. Mehtälä (Eds.), *The Physical Activity Behaviours of Children and Adolescents in Finland; Results of the LIITU Study* (pp. 16-22). Helsinki: State Sport Council Publications 4. https://doi.org/10.1186/s12889-016-3591-y

Jayanthi, N. A., LaBella, C. R., Fischer, D., Pasulka, J., & Dugas, L. R. (2015). Sports-Specialized Intensive Training and the Risk of Injury in Young Athletes. *The American Journal of Sports Medicine, 43,* 794-801. https://doi.org/10.1177/0363546514567298

Jayanthi, N., Pinkham, C., Dugas, L., Patrick, B., & LaBella, C. (2013). Sports Specialization in Young Athletes. *Sports Health*: *A Multidisciplinary Approach, 5,* 251-257. https://doi.org/10.1177/1941738112464626

Kokko, S., Martin, L., Geidne, S., Van Hoye, A., Lane, A., Meganck, J., Koski, P. et al. (2018). Does Sports Club Participation Contribute to Physical Activity among Children and Adolescents? A Comparison across Six European Countries. *Scandinavian Journal of Public Health*. https://doi.org/10.1177/1403494818786110

Kokko, S., Selänne, H., Alanko, L., Heinonen, O. J., Korpelainen, R., Savonen, K., Parkkari, J. et al. (2015). Health Promotion Activities of Sports Clubs and Coaches, and Health and Health Behaviours in Youth Participating in Sports Clubs: The Health

Promoting Sports Club Study. *BMJ Open Sport & Exercise Medicine, 1,* e000034. https://doi.org/10.1136/bmjsem-2015-000034

Loveday, A., Sherar, L. B., Sanders, J. P., Sanderson, P. W., & Esliger, D. W. (2015). Technologies That Assess the Location of Physical Activity and Sedentary Behavior: A Systematic Review. *Journal of Medical Internet Research, 17,* e192. https://doi.org/10.2196/jmir.4761

Marques, A., Ekelund, U. M., & Sardinha, L. B. (2017). Associations between Organized Sports Participation and Objectively Measured Physical Activity, Sedentary Time and Weight Status in Youth. *Journal of Science and Medicine in Sport, 19,* 154-157. https://doi.org/10.1016/j.jsams.2015.02.007

Mathisen, F. K. S., Kokko, S., Tynjälä, J., Torsheim, T., & Wold, B. (2019). Leisure-Time Physical Activity and Participation in Organized Sports: Changes from 1985 to 2014 in Finland and Norway. *Scandinavian Journal of Medicine & Science in Sports, 29,* 1232-1242. https://doi.org/10.1111/sms.13431

Matos, N., & Winsley, R. J. (2007). Trainability of Young Athletes and Overtraining. *Journal of Sports Science & Medicine, 6,* 353-367.

Mattila, V. M., Parkkari, J., Koivusilta, L., Kannus, P., & Rimpelä, A. (2009). Participation in Sports Clubs Is a Strong Predictor of Injury Hospitalization: A Prospective Cohort Study. *Scandinavian Journal of Medicine & Science in Sports, 19,* 267. https://doi.org/10.1111/j.1600-0838.2008.00800.x

Moseid, C. H., Myklebust, G., Fagerland, M. W., Clarsen, B., & Bahr, R. (2018). The Prevalence and Severity of Health Problems in Youth Elite Sports: A 6-Month Prospective Cohort Study of 320 Athletes. *Scandinavian Journal of Medicine & Science in Sports, 28,* 1412-1423. https://doi.org/10.1111/sms.13047

Rees, T., Hardy, L., Güllich, A., Abernethy, B., Côté, J., Woodman, T., Warr, C. et al. (2016). The Great British Medalists Project: A Review of Current Knowledge on the Development of the World's Best Sporting Talent. *Sports Medicine, 46,* 1041-1058. https://doi.org/10.1007/s40279-016-0476-2

Sæther, S. A. (2017). Characteristics of Professional and Non-Professional Football Players: An Eight-Year Follow-Up of Three Age Cohorts. *Montenegrin Journal of Sports Science and Medicine, 6,* 13-18. https://doi.org/10.26773/mjssm.2017.09.002

Schlehter, C. R., Rosenkranz, R. R., Milliken, G. A., & Dzewaltowski, D. A. (2017) Physical Activity Levels during Youth Sport Practice: Does Coach Training or Experience Have an Influence? *Journal of Sports Science, 35,* 22-28. https://doi.org/10.1080/02640414.2016.1154593

Sundgot-Borgen, J., & Larsen, S. (1993). Pathogenic Weight-Control Methods and Self-Reported Eating Disorders in Female Elite Athletes and Controls. *Scandinavian Journal of Medicine & Science in Sports, 3,* 150-155. https://doi.org/10.1111/j.1600-0838.1993.tb00379.x

Tremblay, M. S., Carson, V., Chaput, J. P. et al. (2016). Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *Applied Physiology, Nutrition, and Metabolism, 41,* S311-S327. https://doi.org/10.1139/apnm-2016-0151

Tucker, R., & Collins, M. (2012). What Makes Champions? A Review of the Relative Contribution of Genes and Training to Sporting Success. *British Journal of Sports Medicine, 46,* 555-561. https://doi.org/10.1136/bjsports-2011-090548

Vähä-Ypyä, H., Vasankari, T., Husu, P., Mänttäri, A., Vuorimaa, T., Suni, J., & Sievänen, H. (2015). Validation of Cut-Points for Evaluating the Intensity of Physical Activity with Accelerometry-Based Mean Amplitude Deviation (MAD). *PLoS ONE, 10,*

e0134813. https://doi.org/10.1371/journal.pone.0134813

World Health Organization (2010). *Global Recommendations on Physical Activity for Health*. Genève: Author. https://www.who.int/dietphysicalactivity/global-PA-recs-2010.pdf