

The motor and leisure time conditioning of young table tennis players' physical fitness

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Research

Keywords: leisure activities, young athletes, table tennis, motor fitness

Posted Date: July 8th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-40434/v1>

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Version of Record: A version of this preprint was published at International Journal of Environmental Research and Public Health on August 8th, 2020. See the published version at <https://doi.org/10.3390/ijerph17165733>.

Abstract

Background: This study aimed to determine what factors influence the level of physical fitness of young athletes. Its purpose was therefore to assess the association between physical fitness and objectively measure the lifestyle determinants of elite junior table tennis players.

Methods: The basic anthropometric characteristics (body height and body weight) were collected of 87 Polish table tennis players (girls and boys, at different stages of sport training) aged 9–12 years. The level of special fitness tests from the Table Tennis Specific Battery Test were used, assessing reaction speed and displacement speed. All eight International Physical Fitness Test trials were also used to determine the level of general fitness of the participants. Selected questions from the Health Behaviour in School-Aged Children questionnaire were asked to measure factors associated with leisure time.

Results: The findings confirm a relationship between sedentary forms of leisure time activity and the training of young players being at the targeted stage. Moreover, competitors with longer training experience more often chose active forms of spending free time.

Conclusion: Knowledge of the global physical activity undertaken by young athletes during their leisure time provides a better understanding of their individual needs, and may help young table tennis players to succeed at a world-class level in the future.

Background

Table tennis is a complex and technically difficult game because the player must act quickly, accurately and in changing conditions. As Limoochi [1] and Faber et al. [2] observed, table tennis is regarded as an early entry sport and associations already try to find high-potential players at a young age. Table tennis performance itself at such a young age is influenced by individual differences in growth, maturation, training experiences, competition participation and environmental factors (including leisure time). These factors may affect a player's sport potential [3–5].

Several authors have studied the relationship between various anthropological variables and body composition for success in table tennis [6–8]. However, some research states that between the ages of 10 and 14 years, no distinct anthropometric player profile exists [1, 9].

Table tennis is characterised by highly developed motor skills such as agility [10] reaction speed time [11, 12], explosive power and strength [13], eye movement and coordination [14]. According to Bandi [15] table tennis game skills include such traits as grip, attitude or playing position, types of punches and leg movements.

In physiological terms, table tennis belongs to endurance- and speed-based disciplines with changing modes of effort and intensity. Due to the short, high-intensity periods under anaerobic metabolism that

characterise a match, the most important physical capacities of table tennis players are endurance and velocity. However, strength, coordination and agility may also play a key role in this sport [16–18].

Literature addressing the characteristics of youth table tennis players is not extensive. Three objectives of performance analysis are relevant to the study of young table tennis players. Technique analysis is concerned with the mechanical aspects of technique and how skills translate into performance [19, 4, 20]. Tactical analysis is concerned with strategies and tactical decisions that are manifested in a game [21, 22]. Physical aspects of performance can be determined through analysis and estimates of game intensity [23]. Other preliminary research has shown that motor ability skills such as speed while dribbling, aiming at a target, ball skills and eye-hand coordination seem to be promising ways to distinguish between talented and less talented young players [19, 24, 25, 14].

However, an even more expansive array of methods can be used in performance analysis of child and youth table tennis. An interesting direction of future research seems to be the study of the relationship between players' special fitness and their leisure time interests. Such studies are particularly important for this age group of table tennis players. In this sports discipline, the number of hours of training per week is especially high at a young age [5]. Youth table tennis players, especially representatives of the national youth team, are confronted with high physical, psychological and social demands [26, 27].

The available literature discussing young table tennis players has ordinarily focused on specific items viewed as relevant to the sport and recreation, separate to variation in the growth and maturity (including social maturity) characteristics of the players [28]. Although physical training in table tennis is an obviously important factor for sport success, there is a lack of evidence that at the same level of training, young athletes who also have well-organised and diverse activities in their free time achieve the best results. Leisure activities awaken, deepen, direct and consolidate the interests of children and young adults, and increased activity stimulates action and boosts motivation to show initiative. Knowledge of the global physical activity undertaken by athletes during their leisure time and their preferences provides a better understanding of their individual needs – and may help young table tennis players to succeed at a world-class level in the future.

In the scientific and methodological literature, numerous works have been devoted to the influence of social environment factors on the physical performance of children playing table tennis, and this has determined the relevance of this study. Therefore, this study crucially aimed to determine what factors influence the level of physical fitness of young table tennis players. To achieve this goal, our study was twofold, addressing both physical fitness and leisure activities of young top-level table tennis players. The purpose of this study was to assess the association between physical fitness and objectively measured lifestyle determinants (leisure time physical activities and sedentary behaviour [SB]) of elite junior table tennis players (girls and boys, at different stages of sport training).

Methods

Participants

The study group consisted of young Polish table tennis players from the teams of two provinces: Dolnośląskie and Wielkopolskie ($n = 87$). They were born in 2002–2007 and training in table tennis at the targeted or specialised sports training stage (according to the guidelines of the National Table Tennis Development Program in Poland for 2018–2033). The targeted training stage includes players aged 9–12 years, and the specialised training stage 13–16 years. The study group was selected arbitrarily using the following criteria: written consent from parents to participate in the research, membership in the province team, current license of the Polish Table Tennis Association, a minimum three-year training period, health condition allowing all physical fitness tests to be carried out, and playing style requiring the use of rackets with a so-called smooth lining (excluding people using rackets with atypical cladding, such as anti-spin cladding, short pin or long pin, where play is characterised by a different technique than topspin strokes used in a battery of special tests).

The study was conducted in compliance with the Declaration of Helsinki and was approved by the local ethics committee: the Bioethics Committee of the Karol Marcinkowski Medical University, Poznań, Poland (No. 543/18). All data were analysed confidentially.

Procedures

Anthropometric measurements were taken according to standard procedures, following the guidelines described by Martin and Saller [29]. Stature was measured to the nearest 0.1 centimetre with a stadiometer with the child standing upright. Body mass was measured with a Tanita MC-780 scale (Japan) with GMON software (version 3.2.8). The age to the decimal was calculated using the date of birth (day, month, year) and the date (day, month, year) the anthropometric measurements were taken. Decimal age categories were based on one-year intervals (e.g. 12.50 to 13.49 = 13 years). Growth references for height, weight, and body mass index (BMI) were constructed with the lambda, mu, sigma (LMS) method using data from a large, recent, population-representative sample of school-aged children and adolescents in Poland [30]. Participants were classified as underweight, normal weight or overweight according to age- and gender-specific cut-off points [31].

Special motor fitness

To determine the level of special fitness of young table tennis players, tests from the Table Tennis Specific Battery Test (TTSBT) were used, assessing reaction speed (T1, T2) and displacement speed (T3) [32]. In reaction speed tests, balls are thrown at high speed (70 balls/minute) to different areas of the table tennis table and the player has to perform forehand (T1) or backhand topspins (T2). The tennis of balls that touch the table over 15 seconds is considered successful. In T3, balls are thrown at high speed (80 balls/minute) to the sides of the table and the player should alternately perform forehand and backhand topspins. The tennis of balls that touch the table over 15 seconds is considered successful. The selected options included the use of two strokes considered basic at the stage of targeted and specialised training, topspin forehand and topspin backhand, previously used for similarly aged

participants [23]. The ICC overall absolute agreement of the assessing parameters of the TTST was high (0.85). More specifically, the Cronbach's α for T1 was 0.83, for T2 0.86 and for T3 0.69.

A Tibhar Robo Pro Junior (Germany), a compact machine with an oscillator and remote control, was used to carry out the test samples. For the test, the machine was programmed to throw balls without rotation and with a central ball spread angle. The balls were thrown in the following variants: (1) topspin forehand diagonally, (2) topspin backhand straight, and (3) mixed attempt to play once with topspin forehand and once with topspin backhand with the machine in the centre of the table. Before the start of each test sample, the competitors performed a block of shaping exercises and special exercises and were informed about the correct way of performing the test samples.

Motor fitness

All eight International Physical Fitness Test (IPFT) trials were used [33] to determine the level of general fitness of the participants. The IPFT components were the 600 or 800 metres (girls 12–19 years old) or 1,000 metres (boys 12–19 years old) long run test (LOR); the handgrip strength test, measuring the maximal strength of the upper limb using a calibrated and adjustable hand dynamometer (HGR); the standing long jump test, measuring the lower limb power (SBJ); the bent arm hang test, measuring the upper limb endurance strength (BAH); the sit-ups in 30 seconds test, measuring muscular endurance of the trunk and hip flexors (SUP); running speed – 50 metres run (50mR); the speed shuttle run test of 4 × 10 metres, measuring speed and agility (SHR); and the sit and reach test, measuring agility (SAR). All tests were carried out in one day. Assessment of the results of the movement tests was made using scoreboards developed according to calendar age groups, separately for each gender. The classification standard for each of the individual IPFT trials is 50 points. The overall fitness index (OF) was used to assess the level of physical fitness.

Lifestyle

Selected questions from the Health Behaviour in School-Aged Children (HBSC) questionnaire were asked [34, 35] to measure factors associated with leisure time. Cronbach's α , a measure of internal reliability, was obtained for the scale, showing a reliability of the total of 0.88. Time spent in leisure time, specifically moderate to vigorous physical activity (MVPA) and vigorous physical activity (VPA), was measured using a Physical Activity Screening Measure [36]. Reliability was established at ICC = 0.77 and validity $r = 0.40$. This measure has been used earlier in population studies in Poland [37, 38]. Participants were asked to answer two questions. Q1: Over the past seven days, how many days were you physically active for a total of at least 60 minutes per day? Q2: Over a typical or usual week, how many days are you physically active for a total of at least 60 minutes per day? Prochaska et al. [36] found these questions to be reliable and to have acceptable validity in comparison with accelerometer data. The MVPA index was calculated based on the following formula: $MVPA = (Q1 + Q2) / 2$, where MVPA = PA index, Q1 is the total of physically active days during the past seven days, and Q2 is the number of physically active days during a typical week.

The VPA index was calculated based on the question: outside of school hours, how often do you usually exercise to such an extent that you get out of breath or sweat? The response categories were 'every day', '4–6 times per week', '2–3 times per week', 'once a week', 'once a month' and 'none at all'. This index has been found to have at least partial validity, as Booth et al. [39] found that adolescents who reported higher levels of VPA outperformed those with lower VPA on a running test. Children and youth aged 5–17 years should accumulate at least 60 minutes of MVPS daily. VPA should be incorporated, including those that strengthen muscle and bone, at least four times per week [35].

Leisure time spent on screen-based sedentary behaviours was assessed through three questions. SB1: About how many hours a day do you usually watch television (including videos) in your free time? SB2: Approximately how many hours a day do you play PC games or TV games (PlayStation, Xbox, Game-Cube, etc.) in your free time? SB3: Approximately how many hours per day do you use a PC for chatting online, surfing the internet, writing emails, homework, etc. in your free time? The following nine response options were the same for all three questions: 'none at all', 'about half an hour a day', 'about 1 hour a day', 'about 2 hours a day', 'about 3 hours a day', 'about 4 hours a day', 'about 5 hours a day', 'about 6 hours a day' and 'about 7 or more hours a day'. Vereecken et al. [40] evaluated the test–retest reliability and relative validity of the questions assessing screen-based sedentary behaviours and found no systematic difference between test and retest (ICC = 0.76 for boys and ICC = 0.54 for girls).

Data analysis

Descriptive statistics are presented as mean and standard deviation or range (minimum–maximum). The difference in mean results between two independent groups was checked using Student's t-test for independent samples. The normality of the distributions was checked using the Kolmogorov–Smirnov test. In the event of failure to meet the Student's t-test assumption about the normality of the distribution of the studied variable, and in the case of ordinal variables, the Mann–Whitney U test (Z) was used to check the significance of differences. Correlations between variables were checked using the Spearman's rank correlation coefficient (r_s). The level of significance was set at 0.05. IBM SPSS Statistics 23 (IBM Corp., Armonk, New York, USA) was used for the statistical analyses.

Results

This study analysed the data of 87 young table tennis players (age 13.4 ± 1.74 years). The sample characteristics and descriptive results are presented in Table 1. More than half of the players were 13 years old.

Table 1
Demographic characteristics of the players

Variable	girls (n = 38, 43.7%)		boys (n = 49, 56.3%)	
	M ± SD	Min-Max	M ± SD	Min-Max
age (years)	13.4 ± 1.76	10.7–16.5	13.7 ± 1.75	11.0–17.0
body weight (kg)	47.2 ± 8.97	30.1–63.2	55.1 ± 14.15	28.4–92.2
body height (cm)	158.2 ± 8.99	141.0–178.5	165.0 ± 11.81	138.0–189.9
BMI	98.0 ± 12.61	80.1–145.1	106.2 ± 16.15	73.5–137.2
targeted stage of sport training (n,%)	23, 60.5%		27, 55.1%	
specialized stage of sport training (n,%)	15, 39.5%		22, 44.9%	
M– mean, SD – standard deviation, Min. – minimum value, Max. – wartość maximum value				

Based on BMI calculations (according to Cole, Lobstein) [31]), nearly 55% of the surveyed players displayed a proper level of nutrition of their body, while 27% were diagnosed with overweight and the remaining 18% with underweight. The analysis showed that boys had higher results than girls for BMI (according to Cole; $Z = -2.66$, $p = 0.008$).

The average OF index score of all participants was 424.1 ± 41.69 points. There were statistically significant differences between the results of girls and boys ($p = 0.036$), with higher test results obtained by girls. Such differences were also found for the majority of IPFT tests ($p < 0.05$), but no significant differences were found for the measurements of hand muscle strength ($p = 0.839$) or torso inclination ($p = 0.06$; Table 2).

Table 2
Results of IPFT – comparison by gender

Variable	Boys		Girls		Test t Studenta or U	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t/Z</i>	<i>P</i>
OF [pts]	412.5	43.75	439.1	33.87	-3.10*	0.003
50mR [pts]	55.2	8.30	58.7	6.44	-2.14*	0.036
SBJ [pts]	52.4	7.97	58.2	8.18	-3.30*	0.001
LOR [pts]	50.8	6.22	54.5	5.76	-2.81*	0.006
HGR [pts]	45.4	6.85	49.8	9.01	-2.59*	0.011
BAH [pts]	52.5	8.60	52.7	8.23	-0.14*	0.893
SHR [pts]	55.8	7.57	60.8	8.21	-2.98*	0.004
SUP [pts]	52.2	8.29	55.2	6.71	-2.16**	0.031
SAR [pts.]	50.9	6.01	49.2	5.62	-1.88**	0.060
<i>M</i> – mean, <i>SD</i> – standard deviation, * <i>t</i> – Student t-test value, ** <i>Z</i> – Mann-Whitney U test value. <i>P</i> – level of significance,						

There were no differences in the total point index between the groups separated by training stage ($p = 0.077$). Table 3 presents the results obtained by young table tennis players in three special fitness tests.

Table 3
Results of TTSBT – comparison by gender

Variable	Boys		Girls		U Manna-Whitneya test	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>Z</i>	<i>P</i>
Test 1	13.4	3.32	13.6	3.08	-0.34	0.734
Test 2	13.1	3.91	13.4	3.17	-0.40	0.686
Test 3	10.9	3.03	10.4	3.05	-0.68	0.496
	targeted stage		specialized stage		<i>Z</i>	<i>P</i>
Test 1	12.5	3.16	14.8	2.77	-3.28	0.001
Test 2	12.0	3.52	14.9	2.98	-3.96	< 0.001
Test 3	9.8	3.09	11.9	2.54	-3.47	0.001
<i>M</i> – mean, <i>SD</i> – standard deviation, <i>Z</i> – Mann-Whitney U test value, <i>p</i> – level of significance						

Statistical analysis did not show significant differences in the results of TTSBT trials between boys and girls. However, it showed that in all test trials, significantly higher results were obtained by competitors at the specialist stage of training.

Table 4
Correlations between special and general physical fitness

Variable	Test 1		Test 2		Test 3	
	r_s	p	r_s	P	r_s	P
OF	0.26	0.016	0.24	0.026	0.18	0.101
R50m [pts]	0.26	0.014	0.23	0.034	0.19	0.084
SBJ [pts]	0.16	0.129	0.24	0.024	0.13	0.215
BAH [pts]	0.32	0.003	0.36	0.001	0.24	0.027
SHR [pts]	0.18	0.095	0.29	0.006	0.12	0.263
SAR[pts.]	0.21	0.056	0.21	0.052	0.23	0.029
r_s – Spearman rank correlation coefficient, p – level of significance						

Young table tennis players, characterised by high general efficiency (high OF values), achieved higher results in T1 and T2. The relationship between the general fitness area and the special fitness area of young table tennis players applies only to selected test samples (Table 4). There were no significant differences related to the players' gender or differences between the groups based on the stage of training.

The average number of days a week allocated to PA by young table tennis players in their leisure time was 5.5 ± 1.62 , while exercise at high intensity (VPA) was performed on average on 4.1 ± 0.95 days a week. Statistical analysis did not show any significant differences between MVPA and VPA ratios by gender (Table 5). A statistically significantly higher VPA level was found among competitors at the specialist stage of training ($Z = -3.13$, $p = 0.002$). In addition, MVPA standards were met by 38% of young table tennis players, and VPA standards by 66%.

Boys used computer games on school days and holidays (SB2) statistically significantly more often than girls. No other statistically significant differences were found in leisure time activity (S1, S3) between groups by gender.

Table 5
Descriptive statistics for SB

Variable	Boys		Girls		U Manna-Whitneya test	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>Z</i>	<i>P</i>
MVPA (days)	5.6	1.50	5.3	1.77	-0.75	0.453
VPA (days)	4.2	1.01	4.0	0.87	-0.81	0.420
SB2 (school/weekend days)	3.0/4.6	1.67/2.25	1.8/2.5	1.35/1.31	-3.52/-4.72	< 0.001
<i>M</i> – mean, <i>SD</i> – standard deviation, <i>Z</i> – Mann-Whitney U test value, <i>p</i> – level of significance						

The use of a computer, tablet or smartphone (SB3) on school days ($Z = -2.93$, $p = 0.003$) and days off ($Z = -2.12$, $p = 0.034$) was significantly more frequent among the respondents at the targeted stage of training.

The analysis of the collected data showed that the most common forms of PA undertaken in leisure time were walking and cycling. Over half of the respondents devoted at least 2–3 hours a week to this activity. No statistically significant differences existed between girls and boys in their choice of leisure activities. The stage of sport training was also not crucial in choosing recreational forms of physical activity. The correlation analysis showed no statistically significant relationship between the special fitness area (TTSBT) and the leisure time activity of the table tennis players.

Discussion

This study was a novel attempt to analyse the relationships between selected fitness characteristics and some objectively measured lifestyle determinants in a group of elite young table tennis players in Poland. In recent years, researchers have been increasingly interested in the correlations between various lifestyle determinants and the level of physical fitness among adolescent athletes [41, 42]. However, no scientific reports exist on the relationship between environmental factors such as leisure time activities and the level of general and special fitness among young table tennis players.

Many authors have attempted to assess the physical fitness of young people practicing sport, including table tennis, treating it as an isolated variable, as exemplified by the research of Ulbricht et al. [43], Kramer et al. [44, 45] and Faber et al. [5] The results presented in the study show that all the examined players presented an average level of general physical fitness ($OF = 424.1 \pm 41.69$) estimated according to standards for Polish youth [33]. The results of other studies, including Żak et al. [46] and Łubkowska and Troszczyński [47], show that athletes practicing other sports (e.g. badminton, Olympic taekwondo or swimming) who are the same age as the examined table tennis players achieved a similar OF value.

The higher level of OF of girls practicing table tennis, compared to their male peers, can be explained, among other factors, by their faster biological maturation at the investigated age [48, 44, 49]. A comparative analysis of the average results of girls and boys showed that not all IPFT results were above

the average classification standards (Table 2). In the hand strength test, both girls and boys obtained results below norms. An analysis of the results of dynamometer measurement of hand strength of girls and boys reported that this test was insufficient to represent total strength at this stage of development [50].

The girls also obtained worse results in the test of flexibility. The low point indicator of the players in this sample is described in the literature on the subject [51, 52]. The optimal level of flexibility is, however, necessary in table tennis for the correct performance of technical elements [28]. Therefore, there is a need to increase the training measures that shape flexibility in the motor training process of these young players. Table tennis belongs to the group of sport disciplines where the level of coordination and speed skills, especially of the upper limbs, should be at the highest level [53–56]. This study showed that the table tennis players obtained the best results in the SHR test assessing the level of these abilities. These results are consistent with those obtained for players on the Polish youth teams of the same age in other sports, including swimming, Olympic taekwondo, football, acrobatics, boxing, judo, canoeing, cycling, basketball, athletics, handball, volleyball, fencing, triathlon, rowing and free wrestling [57, 47].

The assessment of the level of special physical fitness in young top-level table tennis players has not yet been widely studied [58]. Sport-specific technical skills are predominant factors, although a complex profile of physical performance factors is also required. For this reason, accurate and reliable methods of evaluation are very important for the training process. The review of literature revealed that most of the studies designed tests for speed or accuracy of basic skills, other aspects of physical fitness or counterattack [59, 23]. As determined by Kastikadelis [23] contemporary playing techniques in table tennis are very important for target precision counting and the accurate reflection of players' strokes. The TTSBT is a reliable test battery that focuses on the evaluation of technical skills and the progress of table tennis performance of young players [23, 21].

However, so far, no appropriate test standards have been developed for young tennis players based on their age; the only available standards are based on the gender of the players [32]. When analysing the results obtained by the examined players in relation to the available standards, it should be noted that in T1 and T2, both girls and boys were classified as having a good and a very good level of special fitness, respectively. In T3, on the other hand, the level was basic and good [32]. The TTSBT results obtained by girls did not differ significantly from the boys' results (Table 3). Perhaps this is because the individual level of differentiation of the respondents was low (high group homogeneity) and the sample size was limited. Similar relationships have been reported by Chillon et al. [60], among others. However, differences based on the stage of training were noticeable, probably because of the significantly higher volume and intensity of training [13, 9].

The relationship between the tests characterising the level of general and special physical fitness of young players is interesting. The results of T1 and T2, whose main purpose was to estimate each player's capacity to react quickly to unpredictable throwing of balls were significantly connected with the upper (BAH) and lower (SBJ) body power of the players (boys and girls, at both stages of training) and with

their running and speed abilities (SHR and R50m). The results of the study correspond with the findings of Kramer et al. [44] and Faber et al. [5], who studied junior elite tennis players in the Netherlands. In turn, the results of T3 were connected with upper body power (BAH) and body agility (SAR) of young players (Table 4). This was due to the characteristics of the test sample, with the main purpose to estimate the players' capacity to perform lateral, lateral with pivot, profundity and mixed displacements during a short period. A possible reason for these findings is that agility, speed and strength of upper limbs includes dynamic movements requiring high muscle power, so one would therefore expect these performances to be closely related. Another explanation for the close correlation between these skills may be the same energy systems that each movement type demands [60].

One of the main goals of this study was to identify young table tennis players' leisure time physical activities and SB between training. The level of PA (MVPA and VPA) and sedentary lifestyle (SB) outside the training of young athletes will allow trainers to understand the interests of their players better and may affect the individualisation of the training process. According to Exel [61], it is difficult for young athletes and trainers to determine the best choices of leisure time strategy, but individualisation of needs and a context-based approach in daily life schedule structure seems to be critical. For young athletes, considering table tennis performance, PA and SB profiles should also be considered key to evaluating, preventing and treating overtraining symptoms [62]. The level of PA and SB between training may also highlight issues related to the health parameters of young athletes. PA at moderate to vigorous intensity can help prevent weight gain and maintain a healthy body weight in children and adolescents [63]. Current PA guidelines for children and youth aged 5–17 years recommend at least 60 minutes of MVPA per day and VPA at least four times per week [64], but nationally, only a small proportion of youth meet these guidelines [65]. Moreover, more than two thirds of European youth can be categorised as insufficiently active [66, 61]. In our study, MVPA standards were met by 38% of young table tennis players, and VPA standards by 66% (Table 5). Although young athletes mostly performed MVPA above the recommended level and were also active in their leisure time, sedentary lifestyle habits associated with daily activities and social behaviours of young people were also visible. According to Pearson et al. [67] young elite athletes prefer to sit down as often as possible to aid recovery and prevent fatigue. This suggests that some active children choose to spend considerable time being sedentary (TV watching, cell phone interaction, recreational computer use or other forms of screen-based entertainment), as confirmed by the research of de Rezende et al. [68]. Thus, it can be assumed that the studied young elite table tennis players, exposed to many hours of training and competition, more often adopt a sedentary lifestyle, treating it as a form of rest and relaxation. This is also reflected in the forms of PA undertaken by the examined table tennis players (girls and boys) in their leisure time (walking and cycling), which are characterised by low physical effort. The results of this study do not confirm completely the assumption of a difference in terms of gender and stage of sport training in the leisure time activities of young table tennis players.

The main limitation of this study that should be highlighted is that it assessed only young Polish table tennis players, and further studies should be performed with athletes of different nationalities. The relatively small group sizes present another limitation. The current study did not examine other potentially

influential factors (such as differences in maturation, which might influence the physical fitness results, family leisure time and sport traditions, motivation, parental and peer support, training facilities and school policies), which might also be considered a limitation. However, the similar cultural backgrounds of the examined players (coming from urban areas of cities) may be an advantage.

Conclusions

The results presented indicate an innovative way of combining important variables in the context of child and youth sport, namely assessment of the level of physical fitness and the quality of free time use between training. The results confirm a relationship between sedentary forms of leisure time activity (screen-based entertainment) and the training stage of young players. This relationship occurred only in the group of players at the targeted stage of training. Although no significant relationships were found at the specialist stage of training, the fact that competitors with longer training experience more often chose active forms of spending free time (such as cycling and jogging) is noteworthy. Although this was not studied, we believe it fits in very well with the training process, being a kind of individually implemented training with the character of active regeneration, with a low intensity level. These types of activities, in addition to the basic variables such as proper nutrition, hydration and sleep, can contribute to achieving full readiness for the physical loads implemented the next day in specialist training of young table tennis players.

Because proper recovery is essential for the quality of training, the reported sedentary lifestyle of elite young table tennis players should not be a problem. This information may provide useful data for trainers in helping them control the loads that may influence training performance as well as the health condition of young table tennis players.

Abbreviations

BAH: upper limb endurance strength test; BMI: body mass index; HBSC: Health Behaviour in School-Aged Children questionnaire; HGR: the handgrip strength test; IPFT: International Physical Fitness Test; LOR: long run test; MVPA: moderate to vigorous physical activity; PA: physical activity; SAR: sit and reach test; SB: sedentary behaviour; SBJ: standing long jump test; SHR: shuttle run test of 4 x 10 metres; SUP: sit-ups in 30 seconds test; TTSBT: Table Tennis Specific Battery Test; T1, T2: reaction speed test; T3: displacement speed test; VPA: vigorous physical activity; 50mR: 50 metres running speed test.

Declarations

- **Ethics approval and consent to participate:** the Bioethics Committee of the Karol Marcinkowski Medical University, Poznań, Poland (No. 543/18).
- **Consent for publication:** Not applicable
- **Availability of data and materials:** The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

- **Competing interest:** The authors declare that they have no competing interests.
- **Founding:** This research did not receive any specific grant from founding agencies in the public, commercial, or not-for-profit sectors.
- **Authors' contributions:** BP conceptualized the study, analysed and interpreted the data and was a major contributor in writing the manuscript. The literature search were performed by SG, MK and MA. Screening and article review were performed by BP and MA. Data analysis and synthesis were performed by BP and MA. MA also drafted the manuscript. All authors revised the manuscript and approved the final manuscript.
- **Acknowledgements:** Not applicable

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