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# PARTICIPATION IN COMPUTER GAMES VS. COORDINATION MOTOR ABILITIES AND BODY COMPOSITION IN BOYS FROM RURAL AREAS OF POLAND

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ABSTRACT
**Purpose.** The present study attempted to determine the effect of the number of hours spent playing computer games per week on somatic characteristics and the performance of selected coordination motor abilities. **Methods.** Ninety-seven prepubertal boys from rural areas of southern Poland were recruited. Selected coordination motor abilities were assessed by use of computer tests and a questionnaire was administered to determine the amount of time spent playing computer games. Basic somatic characteristics such as body height, body mass, body fat percentage (%PF), fat mass (FM), fat-free mass (FFM), and body mass index (BMI) were measured. Descriptive statistics were calculated mean and standard deviation ($\bar{x}$, *sd*) for the studied coordination abilities and somatic characteristics. One-way ANOVA for independent samples was employed to determine the differentiation between the results of the studied variables depending on the mean numbers of hours spent playing computer games per week. **Results.** Analysis revealed statistically significant differences between the results and the number of hours spent playing games, specifically for kinesthetic differentiation, spatial orientation, and the speed, accuracy, and precision of movements (in the number of committed errors). The lowest somatic characteristics including BMI was observed in the group of boys who spent the least amount of time playing computer games. **Conclusions.** It was found playing computer games 8 to 11 hours a week positively affected coordination motor ability, although individuals who played more than this amount of computer games had a higher incidence to be overweight or obese.

**Key words:** computer games, coordination, body build, rural population

## Introduction

Many countries have seen a boom in the popularity of computer games. The availability of computer equipment and even wider gaming possibilities brought on by the Internet (online gaming) finds children ever more eager to play computer games, especially when left unsupervised. This state of affairs may pose a serious threat to children's physical and psychological development. Spending more and more time playing computer games may also lead to becoming addicted, which can cause problems such as labile mood, personality disorders, difficulties in concentration, and learning difficulties at school as well as an increased incidence of aggressive behavior. This may be due in part to the violent content of many games, where violence is not penalized and instead rewarded in the form of more points and level advancement. However, analysis of the literature [1, 2] reveals that there is no indisputable evidence linking violent computer games and a rise in violence among teenagers. Nonetheless, others forms of gaming that have become popularized in part by the Internet are online gambling games, which have emerged as significant problem in recent years. Survey results found that individuals felt elated during gameplay but then experienced a drop in mood upon finishing, and led to players having a need to play again as soon as possible in order to improve mood, which, in consequence, can lead to addiction [3, 4].

Spending too much time playing computer games has also been cited as having an adverse effect on physical development. As early as 1998, the World Health Organization [5] warned of a global obesity epidemic. The nature of playing computer games considerably intensifies a sedentary lifestyle and thereby poses an increased risk of obesity. However, this phenomenon is incredibly complex and cannot be explained by single factors such as a lack of physical activity compounded with too much TV and computer games [6–8]; it includes such facets as increased consumption of caloric foods and beverages.

Nonetheless, playing computer games has been claimed to have a number of positive effects. Literature on the subject emphasizes its educational (improving writing and counting skills, learning foreign languages, etc.) and therapeutic role [9]. Some computer games (racing and action games) are credited with stimulating both the development of visual–motor coordination and the thinking and decision-making processes. Computers themselves can also play an important role in health education, rehabilitation, and coping with stress [10–13]. A new generation of video games (e.g., Dance Dance Revolution, Sony Eyetoy Kinetic, Nintendo Wii) can also have an effect on overall fitness, movement control, a reduction in body mass [14–16], and contribute to the prevention of falls among the elderly [17]. In

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light of the abovementioned observations, the aim of this study was to evaluate the relationship between the amount of time spent playing computer games and performance in selected coordination motor abilities and basic somatic characteristics in a group of prepubertal boys.

## Material and methods

The study involved 97 boys (aged 10.30 ± 0.27 years) living in rural areas near Kraków, Poland. The study was carried out according to the ethical standards stipulated by Polish law. The research procedures were approved by the Bioethics Commission at the Regional Medical Chamber in Kraków, Poland (approval No. 51/KBL/OIL/2010) and the boys' parents supplied their informed consent after being told about the aim and the scope of the study. A questionnaire was administered to the boys in order to determine the number of hours they spent playing computer games. It was assumed that the number of hours might differ depending on the day (weekday or weekend) and also due to random events (illness, trip). Therefore, the questionnaire asked about how a typical day appeared in the preceding month, excluding random events, with questions such as: Do you play computer games every day? How many hours do you spend playing computer games on a weekday? How many hours do you spend playing computer games during the weekend?

Average gameplay (activity) amounted to 9.80 ± 5.28, median = 9.0, lower quartile = 6.0, upper quartile = 14.0 h per week. Based on their answers, the respondents were divided into three groups based on the amount of time spent playing computer games: L < $\bar{x}$ – ½ *sd*, A = $\bar{x}$ ± ½ *sd* and H > $\bar{x}$ + ½ *sd*. Group L spent the least amount of time playing computer games (*n* = 34, 4.38 ± 2.63, median = 5.25, lower quartile = 2.5, upper quartile = 7.0 h per week), Group A spent an average amount of time (*n* = 31, 9.65 ± 1.63, median = 9.0, lower quartile = 9.0, upper quartile = 11.0 h per week), and group H was composed of individuals who spent the most amount of time playing (*n* = 32, 15.68 ± 2.94, median = 16, lower quartile = 14.0, upper quartile = 18.0 h per week). Their ages were similar: L (10.35 ± 0.25, median = 10.33, lower quartile = 10.16, upper quartile = 10.58 years), A (10.25 ± 0.27, median = 10.33, lower quartile = 9.92, upper quartile = 10.50 years), H (10.32 ± 0.30, median = 10.33, lower quartile = 10.0, upper quartile = 10.58 years).

### Testing participants' coordination motor abilities (CMA)

Tests measuring the participants' coordination motor abilities were performed over a period of a few days always from 8 a.m. to 1 p.m., maintaining the same procedures and conditions for each trial (a room which ensured peace and quiet, regulated chair height, the same order of tests for each subject). A tablet computer with a touch screen (Satellite R15, Toshiba, Japan) was used for the tests, which were based on a recent classification of CMA (for more information see [18]). The CMA measured and the adopted procedure can be briefly described as follows:

– kinesthetic differentiation: participants predicted the time necessary to fill in a rectangle, the result of the test was the mean absolute deviation from the pattern expressed in pixels,
– frequency of movements: within a timeframe of 15 s, the participants touched two squares alternately with the tablet's stylus; the result was expressed in the number of touches,
– reaction time to visual or auditory stimuli: after a stimulus was presented, the participants were supposed to click the left button of the mouse as quickly as possible; the result was expressed in milliseconds,
– selective reaction time: depending on the stimulus (auditory or visual), the participant clicked the respective button of the mouse as quickly as possible, the result was expressed in milliseconds,
– movement speed, accuracy, and precision: the participants were to drag a square with the tablet's stylus through a special maze as quickly as possible and with lowest possible number of mistakes; the result of the test was expressed in seconds,
– rhythmization: the object was to memorize a rhythm presented by the computer and then reproduce it; the result was expressed in milliseconds,
– spatial orientation: participants were shown a coordinate plane with two red squares along the *x* and *y* axes, the task was to use the tablet's stylus to plot as quickly as possible the point on the grid where the two red squares would intersect; the result was expressed in seconds,
– eye–hand coordination: the participants used the tablet's stylus to touch a square which was flashed on the screen as quickly as possible; the result was expressed in seconds.

Each test was performed twice (test–retest), with the coefficients of reliability later calculated to be between 0.6 and 0.9, respectively [19]. The tests met the expected reliability requirements measured by an intraclass correlation coefficient (ICC) according to the criteria set forth by Domholdt [20], and were similar to the values found in a similar study by Juras et al. [21], whose ICC coefficients for a maximum deflection test (functional balance) were approximately 0.85.

The basic somatic parameters that were measured included body height, body mass, body fat percentage (%PF), fat mass (FM) fat-free mass (FFM), and body mass index (BMI). Body height was measured using Martin's method. Body fat percentage (PF%) was estimated with a TBF-551 (Tanita, USA) body fat scale that uses bioelectrical impedance analysis. Additionally, the components of BM were also calculated, i.e., the fat mass (FM) and fat-free mass (FFM). The international cut-off points for BM for overweight and obese boys were adopted [22].

Descriptive statistics were calculated ($\bar{x}$, *sd*) for the coordination abilities and somatic traits of the groups according to the number of hours spent playing computer games (Group L – least amount, Group A – average amount, Group H – highest amount). One-way ANOVA was employed for the independent samples in order to determine the variance of the studied parameters among the boys' groups. Tukey's post-hoc test for various *n* values was also used. In addition, the frequencies of the BMI categories were compared using the Chi-squared test. The size, scope and direction of differentiation of the studied traits between the three groups were determined by the value of the normalized intergroup differences. Normalization was carried out for the mean values and standard deviation of the group which reported spending the lowest amount of time playing games. Significance level was set at alpha = 0.05. All statistical analysis was performed using Statistica ver. 6.0 PL for Windows (IBM, Poland).

**Results**

The basic statistical characteristics of the analyzed CMA for the three groups of boys versus the weekly time spent playing are presented in Table 1. The table also provides information on the significance differences of the calculated means based on one-way ANOVA for independent samples. Analysis revealed that statistically significant differences between the group means did exist for kinesthetic differentiation, spatial orientation, and the speed, accuracy and precision of movements (number of errors).

Table 2 presents the results when comparing the participants' somatic parameters. For all the analyzed traits, differences in the arithmetic means among the three groups turned out to be statistically insignificant. However, it should be noted that the lowest somatic characteristics and BMI were found in the group of boys who spent the least amount of time playing computer games. It can also be observed that the boys categorized as playing for only an average amount of time were found to present average somatic characteristics.

Table 3 presents the count, or frequency, of normal, overweight, and obese boys among the L, A, and H groups (BMI age criterion adopted as in Cole et al. [22]). The lowest frequency of boys who were overweight or obese was observed in group L, an average amount in group A, and the highest in group H.

Table 1. Level of coordination abilities vs. time spent on computer games

| Variable (measured unit) | *F* | *p* | Group L | | Group A | | Group H | |
|---|---|---|---|---|---|---|---|---|
| | | | $\bar{x} \pm sd$ | *p* L–A | $\bar{x} \pm sd$ | *p* A–H | $\bar{x} \pm sd$ | *p* L–H |
| Kinesthetic differentiation (pixels) | 5.83 | **0.041** | 53.29 ± 22.55 | **0.019** | 39.97 ± 20.80 | 0.976 | 38.65 ± 13.79 | **0.009** |
| Movement frequency (*n*) | 0.31 | 0.736 | 31.94 ± 6.18 | 0.808 | 32.87 ± 4.89 | 0.997 | 32.96 ± 6.42 | 0.765 |
| Reaction time to visual stimulus (ms) | 2.32 | 0.104 | 317.00 ± 36.49 | 0.095 | 297.77 ± 27.24 | 0.608 | 306.50 ± 42.57 | 0.477 |
| Reaction time to auditory stimulus (ms) | 0.56 | 0.576 | 271.06 ± 37.00 | 0.860 | 266.84 ± 26.38 | 0.872 | 262.81 ± 30.49 | 0.554 |
| Complex reaction time (ms) | 1.45 | 0.240 | 521.97 ± 123.55 | 0.225 | 480.48 ± 60.04 | 0.603 | 504.50 ± 97.95 | 0.757 |
| Complex reaction time (*n* errors) | 1.60 | 0.208 | 3.73 ± 1.81 | 0.646 | 3.12 ± 1.54 | 0.679 | 3.50 ± 1.83 | 0.189 |
| Speed, accuracy and precision of movements (s) | 0.60 | 0.550 | 69.26 ± 13.63 | 0.702 | 66.45 ± 15.14 | 0.978 | 65.75 ± 12.60 | 0.567 |
| Speed, accuracy and precision of movements (no. of errors) | 3.05 | **0.051** | 21.70 ± 11.11 | 0.293 | 17.96 ± 7.50 | **0.004** | 24.01 ± 10.21 | 0.601 |
| Rhythmization (ms) | 1.38 | 0.257 | 160.82 ± 91.73 | 0.429 | 136.06 ± 77.48 | 0.965 | 131.03 ± 61.69 | 0.285 |
| Visual–motor coordination (s) | 1.32 | 0.272 | 55.29 ± 12.10 | 0.362 | 52.06 ± 6.06 | 0.998 | 52.09 ± 8.39 | 0.357 |
| Spatial orientation (s) | 3.57 | **0.032** | 97.08 ± 21.84 | **0.030** | 84.22 ± 14.24 | 0.573 | 89.25 ± 2149 | 0.251 |

Results in bold denote significant differences between averages on the significance level alfa = 0.05

Table 2. Height, body mass, and body composition for the boys playing computer games

| Variable (measured unit) | *F* | *p* | Group L | | Group A | | Group H | |
|---|---|---|---|---|---|---|---|---|
| | | | $\bar{x} \pm sd$ | *p* L–A | $\bar{x} \pm sd$ | *p* A–H | $\bar{x} \pm sd$ | *p* L–H |
| Body height (cm) | 1.48 | 0.232 | 140.90 ± 8.37 | 0.250 | 144.26 ± 8.69 | 0.402 | 141.59 ± 7.29 | 0.947 |
| Body mass (kg) | 1.70 | 0.188 | 35.61 ± 9.41 | 0.180 | 40.52 ± 13.21 | 0.760 | 38.58 ± 9.59 | 0.519 |
| % PF | 1.89 | 0.157 | 18.65 ± 7.01 | 0.202 | 22.40 ± 10.56 | 0.979 | 21.97 ± 7.91 | 0.272 |
| FM (kg) | 2.15 | 0.123 | 7.09 ± 4.37 | 0.117 | 10.30 ± 8.66 | 0.723 | 9.07 ± 5.25 | 0.426 |
| FFM (kg) | 0.78 | 0.462 | 28.51 ± 5.86 | 0.450 | 30.22 ± 5.52 | 0.869 | 29.51 ± 5.16 | 0.754 |
| BMI (kg · m$^{-2}$) | 1.60 | 0.208 | 17.69 ± 2.99 | 0.284 | 19.07 ± 4.26 | 0.998 | 19.02 ± 3.34 | 0.299 |

%PF – % fat mass; FM – fat mass; FFM – fat-free mass

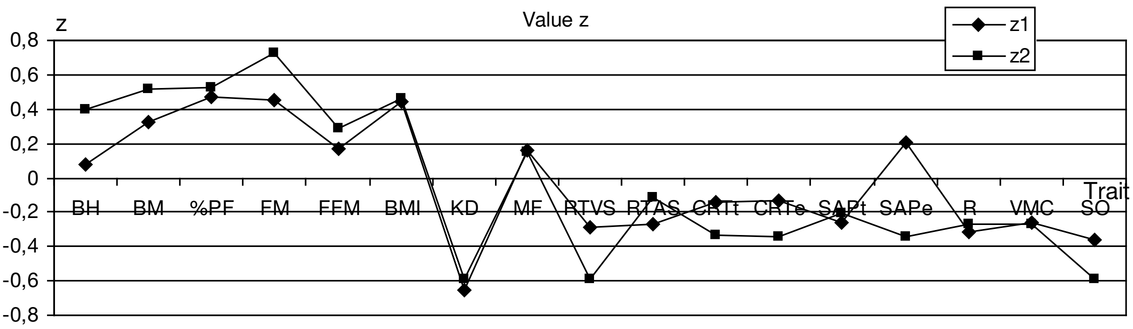
Table 3. The count or frequency of normal, overweight and obese boys by L, A, H groups (BMI age-criterion by Cole et al. [22])

| | Normal | Overweight and obese | Total |
|---|---|---|---|
| L | 29 85.29% | 5 14.71% | 34 35.05% |
| A | 22 70.97% | 9 29.03% | 31 31.96% |
| H | 20 62.50% | 12 37.50% | 32 32.99% |
| Total | 71 73.20% | 26 26.80% | 97 100.00% |

Chi$^2$ = 4.481; df = 2; $p$ = 0.106

Figure 1 presents the profiles of intergroup differentiation in performing the coordination motor abilities. The boys who spent the longest amount of time playing computer games were found to feature better results in almost all of the studied CMAs when compared with their less frequently playing peers ($z_1$). Only the number of errors in the test of speed, accuracy, and movement precision in group L was better, although insignificantly, than for group H. Among all of the coordination abilities, the largest difference in favor of the boys from group H was obtained for kinesthetic differentiation. Considering the normalized differences between group A and L ($z_2$), it can be seen that the best results of the CMAs are found in the boys from group A, those who spend more time playing games, when compared with group L. However, the normalized differences are largely insignificant and oscillate for most of the traits within –0.11 ÷ –0.27 $sd_{GrL}$ except for kinesthetic differentiation, reaction time to visual stimulus, and spatial orientation ($z_2$ = –0.59 $sd_{GrL}$).

Figure 1 also presents the normalized intergroup differences for the somatic characteristics. Normalized differences between the extreme groups ($z_1$) are slightly larger than for coordination abilities. They point to the fact that group H demonstrates higher body mass, body fat percentage, fat mass, and BMI compared with their peers from group L. The normalized differences for these traits were 0.32 ÷ 0.47 $sd_{GrL}$. Such unfavorable tendencies are even more noticeable in the relationship between groups A and L ($z_2$). For the analyzed somatic




BH – body height; BM – body mass; %PF – %fat mass; FM – fat mass; FFM – fat-free mass; BMI – body mass index; KD – kinaesthetic differentiation, MF – movement frequency; RTVS – reaction time to visual stimulus; RTAS – reaction time to auditory stimulus; CRTt – complex reaction time (time); CRTe – complex reaction time (errors); SAPt – speed, accuracy and precision of movements (time); SAPe – speed, accuracy and precision of movements (errors); R – rhythmization; VMC – visual–motor coordination; SO – spatial orientation; $z_1 = (\bar{x}_{GrH} - \bar{x}_{GrL})/sd_{GrL}$; $z_2 = (\bar{x}_{GrA} - \bar{x}_{GrL})/sd_{GrL}$

Figure 1. Normalized differences in measurement CMA, body build, and body composition

parameters, the normalized intergroup differences ranged higher (0.29 ÷ 0.73 $sd_{GrL}$).

**Discussion**

Surveys show that computer games have become a very popular form of entertainment among prepubertal Polish boys, who spend on average nearly 10 hours a week playing computer games, with nearly 10% of boys playing upwards of 20 hours a week. However, boys who play for so long may exhibit the beginning phases of addiction, especially when they become older. It has been confirmed by a study on Australian children that the amount of time spent on computer games rises together with age [23]. American children aged 8 to 18 years were found to spend as much as 6 hours and 47 minutes a day watching TV [24]. Although television remains the major factor in promoting a sedentary lifestyle, participation in computer games is quickly rising with a typical child now playing about 2 hours per day [24].

The results of the present study are congruent with the results of Wack and Tantleff-Dunn [13], who reported that young Americans spend nearly 9.73 hours a week playing games. One especially worrying aspect these researchers mentioned was that almost 10% of the sample of American youth played almost 35 hours a week. None of the participants of the present study reported spending as much time playing computer games.

Nonetheless, one study does point to a number of potential benefits of computer and computer game use [25], which were cited to improve youth's knowledge, skills, attitudes and behavior in terms of health and physical activity. Moreover, new physically interactive electronic games are likely to have a positive effect on young individuals' physical fitness, motor abilities, and their motivation to exercise. However, as of yet there is not enough empirical evidence to support the widespread use of educational electronic games, as current findings provide rather vague examples of their positive effects.

There are relatively few studies investigating the effects of computer games on CMA; the few available focus mainly on eye–hand coordination and reaction time. Such studies evaluated the differences in reaction time in a group of children who regularly played computer games and a non-playing control group and found that the practical experience gained from playing games may have led to improvement of the above-mentioned CMAs [26–28]. Additionally, Dye et al. [29] showed that video games shortened reaction time without a loss in accuracy. These findings were also confirmed by the authors of the present study when investigating the effects of video games on simple and complex reaction time to an auditory stimulus. Boys who spent more time playing computer games had shorter reaction times and made fewer errors compared with their peers who were less involved in gaming. Griffith et al. [30] also demonstrated that computer and video game players showed enhanced eye–hand coordination when compared with their non-playing peers. However, none of these investigations found a statistically significant relationship between visual–motor coordination and the time spent playing computer games. This might point to the fact that individuals with proficient visual–motor coordination are already inclined to choose forms of entertainment that utilize this kind of CMA. Nonetheless, one study further expounded this theory, finding that action games improve visuospatial attention throughout the visual field [31], while another stated that experience gained from playing video games may have led to improved spatial visual perception [11] as well as having a positive effect on learning and benefit some forms of visual perception such as spatial rotation [32]. Dye et al. [33] demonstrated that action video games improved multitasking, which allowed gamers to perform better in tasks with temporal and spatial differentiation. The cited study also showed that computer games had a positive impact on coordination abilities. Similar observations were noted in the present study. Computer games can combine several factors, which, when used together, can provide a number of opportunities in improving visual, kinesthetic, and perceptual functions.

Despite these positives, heavy computer usage nonetheless poses serious risks. Such a sedentary lifestyle may contribute to obesity and lead to less physical activity [34]. A higher incidence of overweight and obese youth in individuals who played computer games for larger periods of time during the weekend was also confirmed by Vicente-Rodríguez et al. [35]. They found that increasing the time spent playing games during the weekend by one hour corresponded to an increased risk of obesity by more than 20%. A literature review [6] did stress caution when drawing overreaching conclusions from rather isolated activities such as watching TV or playing video or computer games. The results of the present study do seem to confirm this observation, as even though boys who spent more time playing computer games demonstrated higher body mass, BMI, and percent body fat, the differences between the groups were found to be statistically insignificant for all somatic traits. This points to the presence of additional factors that need to be taken under consideration in future studies.

**Conclusions**

The number of hours spent playing computer games per week had a positive correlation with the results of various tested coordination motor abilities. The results found that playing about 8 to 11 hours of computer games a week had a positive effect in the performance of various coordination abilities. This positive feedback effect is postulated to work on the development of CMA and on the better use of CMA when solving various visuospatial tasks. However, the study found that individuals who spent additional time playing games did not feature a considerable improvement in coordination abilities and, instead, could be more at risk for featuring negative mood swings and becoming addicted as well as at risk for a higher incidence of being overweight or obese.

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