



Relationships Between Reaction Time, Selective Attention, Physical Activity, and Physical Fitness in Children

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The objective of this study was to analyze the relationships between simple and complex reaction times (RTs) with the physical activity performed weekly, the physical fitness and selective attention in children of the third cycle of primary education. Participants were 119 children aged between 10 and 12 years ($M = 10.71$; $SD = 0.77$). The instruments used for data collection were the D2 attention test to analyze selective attention, various tests of the Eurofit and ALPHA-Fitness Battery to evaluate the physical condition, a bioimpedancimeter Tanita TBF 300 to evaluate the body composition, and the FITLIGHT Trainer to measure the simple and complex RTs. The group that carried out more weekly physical activity used less time in simple ($p < 0.05$, $d = -0.68$, 95% CI $[-1.19, -0.17]$) and complex RT tests ($p < 0.05$, $d = -0.63$, 95% CI $[-1.14, -0.12]$). Also, the results showed that the simple RT was related in a significant way with physical fitness, while the complex RT was related significantly to attentional capacity and physical fitness.

Keywords: reaction time, selective attention, FITLIGHT trainer, physical activity, physical fitness

INTRODUCTION

Reaction time (RT) is a relevant variable in areas such as sports, academics, and other tasks of daily life (Metin et al., 2016; Sant'Ana et al., 2016). It can be defined as the time that elapses from when a stimulus appears until a response is given and is considered a good measure to assess the capacity of the cognitive system to process information (Jensen, 2006; Kuang, 2017). From a physiological point of view, RT is a complex phenomenon whose functioning has been studied by numerous researchers (Kuang, 2017). The RT depends on the speed of the sensorimotor cycle, composed by the detection of the initial stimulus, transfer of the information through the afferent nerves, generation of the response from the central nervous system, and final response (Adleman et al., 2016; Greenhouse et al., 2017).

There are differences between simple and complex RTs. The first is defined as the interval time between when a stimulus appears, its detection, and the given response (Jayaswal, 2016). The second involves the identification and selection of a response to various stimuli (Boisgontier et al., 2014).

The simple RT is significantly shorter than the complex RT (Vences de Brito et al., 2011). The factors that influence the RT are numerous, being able to differentiate between those dependent on the own person and those related to the stimulus (Baayen and Milin, 2010). Among the first can be included the fatigue, physical condition, experience, motivation, gender, age, or dominance of the body member with which one responds. Second, the physical characteristics of the stimulus, its intensity, or duration (Der and Deary, 2006; Woods et al., 2015; Jayaswal, 2016).

In the set of internal factors, the influence of cognitive processes has been described as elements that determine the RT (Deary and Der, 2005; Leckie et al., 2014). Among them, attention would be a variable involved in the RT manifested by a person, which has been suggested in previous research (Prinzmetal et al., 2005; Vaportzis et al., 2013; Jehu et al., 2015). Attention is a cognitive function involved in the activation and selection processes, distribution, and maintenance of psychological activity (Chun et al., 2011; Greimel et al., 2011). It is a process of great anatomical and functional complexity, being able to differentiate manifestations as arousal, focal, selective, divided, alternating, or sustained attention (Petersen and Posner, 2012; Tamm et al., 2013). Specifically, selective attention would allude to the ability to attend to some specific stimuli and ignore others (Giuliano et al., 2014; Gomez-Ramirez et al., 2016).

It has been highlighted that physical activity and sports would be related to improvement in RT (Jain et al., 2015; Okubo et al., 2017; van de Water et al., 2017; Walton et al., 2018). The RT can be deliberately trained (Rabiner et al., 2010; Kirk et al., 2017), and physical activity and sports allow development of a wide variety of actions that would influence its development (Lynall et al., 2018; Walton et al., 2018). It is relevant in individual sports such as swimming or athletics, because it is necessary to respond quickly to start a movement (Nuri et al., 2013; Tønnessen et al., 2013). In other adversary or collective sports, such as badminton, karate, football, or basketball, RT is essential in multiple game situations, because athletes need to make quick decisions to be successful in their actions (Ruschel et al., 2011; Mudric et al., 2015; van de Water et al., 2017). Some studies had also shown that more fit people would be associated with less RT in a set of tasks (Luque-Casado et al., 2016; Westfall et al., 2018).

Previous research had also shown that physical activity and exercise and the improvement of physical fitness could support the development of cognitive functioning and specifically different aspects of attention (Hillman et al., 2009; Kao et al., 2017; Reloba-Martínez et al., 2017). For this reason, it could be considered that the practice of physical exercise and the development of physical condition could have an impact on RT, directly by the training of the capacity to respond to a given stimulus and indirectly by the impact it would have on cognitive functioning (Gentier et al., 2013; Syväoja et al., 2014).

To evaluate the RT, there are instruments, such as the FITLIGHT Trainer™ (FITLIGHT Sports Corp., Canada) or the Dynavision™ D2 Visuomotor Training Device (Dynavision International LLC, West Chester, OH), that have been implemented in different studies (Appelbaum and Erickson, 2018). Specifically, with the FITLIGHT Trainer, several investigations have been carried out. For example,

Zwierko et al. (2014) conducted research with the FITLIGHT Trainer system, which showed that non-athletes had longer RTs than athletes. Likewise, Fischer et al. (2015) used this instrument for the training and analysis of the RT in the United States Air Force. On the other hand, Zurek et al. (2015) investigated the simple and complex RTs of 10 football players who had undergone knee surgery and a rehabilitation program to assess their recovery.

The literature consulted has highlighted the relationships between RT and variables such as selective attention and physical condition, although there are no previous studies that analyze them together in the preadolescent population. Therefore, the objective of the present study was to analyze the relationships between RT, selective attention, concentration, and physical condition in a sample aged from 10 to 12 years.

MATERIALS AND METHODS

Participants

One hundred nineteen students (65 boys and 54 girls) participated in the study, aged between 10 and 12 years old ($M \pm DT$: age = 10.71 ± 0.77 years; height = 1.45 ± 8.21 cm; weight = 42.58 ± 9.87 kg; body mass index = 19.96 ± 3.27 kg/m²; fat mass = $22.73 \pm 8.37\%$) from Alcalá la Real (Jaén, Spain). All of them were in the fifth and sixth years of primary school and did not present any physical or psychological difficulties that could affect the study.

Measures and Instruments

Reaction Time

The FITLIGHT Trainer (FITLIGHT Sports Corp., Ontario, Canada) was used to measure the RT. This is a wireless system consisting of eight sensors, which were placed on a table 1 m high and drawing a semicircle. They had a separation between them of 20 cm, with 40 cm from the central point. To perform the task, the student stood in front of it with his hand in contact with the table. Two tests were performed (simple RT and complex RT). The simple reaction test (SRT) was performed with the dominant hand and consisted of 60 luminous stimuli. The complex reaction test (CRT) was performed with both hands and also consisted of 60 stimuli. In this last one, the visual stimuli were of two colors, blue or green; to the first, one had to react with the left hand, while to the second, one had to react with the right hand. Two sequences of random numbers were programmed for the creation of the tests, one for the SRT and the other for the CRT.

Physical Condition

Physical fitness tests were estimated with ALPHA-Fitness Battery (Ruiz et al., 2011) and Eurofit (1993). The following tests were carried out: (a) manual dynamometry, to evaluate the state of the isometric force in the upper train, in both dominant and non-dominant members (the digital dynamometer model TKK-5401 Grip D, Takei, Tokyo, Japan, was used); (b) horizontal jump test, to estimate the force of the lower train; (c) Course-Navette test to analyze the aerobic capacity of the participants, from which the VO₂max was indirectly estimated (Léger et al., 1988).

For the specific calculation of oxygen consumption, the formula $VO_{2max} = 31.025 + 3.238V - 3.248E + 0.1536VE$ was applied (V = the speed reached in the last completed stage; E = the age of each participant); (d) speed test 5×10 m to analyze travel speed, agility, and general coordination.

Selective Attention and Concentration

The D2 attention test was used (Brickenkamp, 2002). Participants had to selectively attend to certain relevant aspects of the task while ignoring irrelevant ones. The test, in this investigation, was administered collectively and lasted between 8 and 10 min. There are 14 lines with 47 elements each (total = 658 items). The elements were letters “d” or “p,” which are accompanied by small lines at the top or bottom of each letter; these small lines could be in pairs or individually. The work that the participant had to do was to check from left to right each line and to mark every letter “d” that is accompanied by two lines (two above, two below, or one above and one below). The participant had 20 s to complete each line. The scores that can be obtained are as follows: TA (total number of attempts), TH (total number of hits), O (omissions or number of relevant stimuli not crossed out), C (omissions or errors), TET [total effectiveness in the test = $TP - (O + C)$], CON (concentration = $TS - C$), and VAR [index of variation between the last stimulus analyzed between different rows = $(TP+) - (TP-)$]. $TP+$ is the last stimulus analyzed in the row with the most attempted elements, and $TP-$ is the last stimulus analyzed in the row with the fewest attempted elements. This test possesses a test–retest reliability in the original study superior to 0.90.

Anthropometry and Body Composition

Anthropometric data were measured with the Tanita body composition analyzer TBF 300 and the mechanical measuring rod kern MSF 200. Data obtained were height, weight, body mass index, and percentage of fat mass.

Level of Physical Activity and Manual Dominance

An interview was conducted with each subject whose objective was to collect the extracurricular sports activity of each participant in order to separate the participants according to their level of physical activity. The groups were classified into the following: (1) students who did not engage in any type of extracurricular physical activity; (2) students who engaged in 1–3 h of extracurricular physical activity per week; and (3) students who engaged in more than 3 h of extracurricular physical activity per week. Data were also collected from participants on their dominant hand, i.e., whether they were right-handed or left-handed.

Procedure

In order to carry out the research, the participating schools were contacted, and permission was requested from the school management for their participation. In addition, informed and written consent was obtained from parents or legal guardians for students to participate. Throughout the research process, the principles established in the Declaration of Helsinki (World Medical Association, 2013) were respected, and approval was

obtained from the Ethics Committee of the University of Jaén, Spain (Ref. ABR.16/6).

The tests were performed at the school in 2 days. First, anthropometric data were collected from the participants, and then physical condition tests were performed. Anthropometric measurements were taken in the school gymnasium, with light clothing (shorts and t-shirt), without footwear, and without any metallic object on the body (earrings, chains, watches, etc.). Also, to improve the reliability of body composition measures, the following guidelines were indicated: avoid strenuous exercise the previous day, do not significantly alter the diet the day before the test, wear comfortable clothing, control the taking of medicines that may alter body water levels, and do not retain fluids. As for the physical condition tests, the order was as follows: manual dynamometry, horizontal jump, 5×10 m speed test, and 20 m round-trip test. Both were carried out in the school’s sports facilities (multisport courts and gymnasium). The dynamometry, horizontal jump, and speed tests were performed twice, and each participant’s best mark was scored while the Course–Navette test was performed only once.

On the second day, the attention tests and interview were conducted, and the RT was measured. The D2 test was performed collectively in the classroom of the participants. They were previously instructed according to the test manual, and doubts were clarified. The RT was measured in a classroom on an individual basis. First, the simple task was done, and second, the complex task was performed. At the end of the RT test, the student was interviewed to obtain data related to his or her weekly physical activity.

Participants were divided into three groups based on their physical activity habits and routines, not including the physical activity that took place at school during physical education classes. The three groups formed were (a) group 1 ($n = 57$), children who did not carry out any type of physical activity outside school hours; (b) group 2 ($n = 41$), children who carried out between 1 and 3 h a week of physical activity outside school hours; and (c) group 3 ($n = 21$), children who carried out more than 3 h a week of physical activity and/or competed for being federated in some sport.

Statistical Analysis of Data

The RT measured with the FITLIGHT Trainer was studied. The reliability of the device was studied using the intraclass correlation index (IC), the standard error of measurement (SEM), and the minimal difference (MD). In addition to descriptive data, ANOVAs were performed with the RT as a dependent measure and to see its variation depending on the type of task in all cases, taking into account the position of light in the test, the 10 trials in which the subjects responded, and gender and age.

We analyzed the RT in the three physical activity groups by means of ANOVA of a factor, as well as the Bonferroni and Cohen d statistics. Also, correlation analysis (Pearson and Spearman) between physical condition, body composition, and attention measurements with RT values was performed. Linear regression analysis was performed by successive steps to predict the SRT

and CRT from the rest of the variables. Data were analyzed with the SPSS statistical program (SPSS Inc., v.20.0, Chicago, IL, United States).

RESULTS

Reaction Time (FITLIGHT Trainer)

Table 1 shows the RTs for each of the eight sensor positions and the total mean.

A reliability analysis was performed by calculating the ICC, the SEM, and the MD (Weir, 2005). The $ICC_{2,1}$ was calculated for two halves (Wells et al., 2014) by calculating the mean RT for the lights at positions 1, 3, 5, 7 and 2, 4, 6, 8. The type of ICC(2, 1) used considered the effect of trials as a random factor while trials were considered as a sample of possible levels. The results showed $ICC_{2,1} = 0.92$, $SEM = 39.87$, and $MD = 110.51$ ms for the simple task (SRT). For the complex task (CRT), the reliability indices were $ICC_{2,1} = 0.85$, $SEM = 63.50$, and $MD = 176.00$ ms, which can be considered as adequate reliability indices.

ANOVA of repeated measurements was performed to evaluate the effect of the type of task and the position of light in the RT. The Mauchly sphericity assumption was previously analyzed, obtaining significance for the position ($W = 0.11$; $p < 0.001$) and the interaction of both variables ($W = 0.48$; $p < 0.001$), so the Greenhouse–Geisser statistic was used. The results showed that the variable type of task was significant ($F_{1,118} = 982.98$; $p < 0.001$; $\eta^2 = 89$; $1 - \beta = 1.00$) with lower time in SRT, as well as the position of the light ($F_{3,57,420.92} = 32.44$; $p < 0.001$; $\eta^2 = 0.22$; $1 - \beta = 1.00$) and the interaction between both ($F_{5,65,668.53} = 23.15$; $p < 0.001$; $\eta^2 = 0.16$; $1 - \beta = 1.00$). Peer comparisons for light positions showed significant differences ($p < 0.05$) in all cases except for 1–7, 2–8, 3–6, 3–8, 4–5, and 5–6. The lights located at the ends (1, 2, 7, and 8) obtained lower RT, positions 3 and 6 had intermediate RT, and those located in positions 4 and 5 had higher RT.

In the comparisons by type of task and position of light, it was observed that in the RT of the SRT, there were differences ($p < 0.05$) between all the cases except between 1–2, 1–3, 2–8, 3–6, 4–5, and 7–8. In the CRT, all differences were significant ($p < 0.001$ in all cases except between light 1 and all others, as well as couples 4–7 ($p = 0.003$) and 7–8 ($p = 0.006$). It can be seen that in the SRT, the RT increases for the most central positions, while in the CRT, the position with the least RT is position 1, followed by position 7, with the rest having more or less the same times, the greater being that relating to light in position 4.

An analysis of the RT was done according to the test in which the RT was measured with the aim of studying whether fatigue affects the RT differentially. We have considered the average RT for every 10 trials in each subject. Since each of us performed 60 trials, we compared six dozen trials (**Table 2**).

An ANOVA of repeated measurements was performed to study the effect of the type of task and tests in RT, with the Mauchly sphericity test previously performed, being significant for the variable trial ($W = 0.74$; $p = 0.001$) but not for the interaction type of task \times trial ($W = 0.83$; $p = 0.079$). Therefore, only Greenhouse–Geisser was applied in the first case. The variable type of task, as it happened before, was significant ($F_{1,118} = 10,008.22$; $p < 0.001$; $\eta^2 = 0.89$; $1 - \beta = 1.00$), with time being higher in the complex task. In terms of the trial, significant differences were obtained between the six levels ($F_{4,42,521.69} = 19.08$; $p < 0.001$; $\eta^2 = 0.14$; $1 - \beta = 1.00$) and also in the interaction of type of task \times trial ($F_{5,590} = 22.96$; $p < 0.001$; $\eta^2 = 0.16$; $1 - \beta = 1.00$). In the comparisons of Bonferroni by pairs of the trial variable, there was a significance ($p < 0.05$) of the first and second tens with all the others, while there were no differences between the third, fourth, fifth, and sixth tens. That is to say, the RT was lower in the first ten, increased significantly in the second, increased significantly in the third, and did not increase until the end.

As for the interaction in the simple type, differences were found between tens 1–3, 2–3, 2–5, 3–4, and 4–5 ($p < 0.01$) although there is no tendency to increase or decrease as the tens increase, but rather a sawtooth trend was produced, the RT being greater in the odd tens than in the pairs. However, in the complex task, there was an increase in the RT as the tens increased except between the fifth and sixth tens that had practically equal RT although only these increases are significant between the first ten compared with all the others ($p < 0.01$) and the second ten compared with the fifth ($p < 0.01$) and sixth ($p = 0.04$) tens.

Finally, with regard to the FITLIGHT system, the aim was to study whether there were differences between the RTs according to the two tasks in terms of gender and age (**Table 3**).

ANOVA showed significant differences for the variable type of task ($F_{1,113} = 822.97$; $p < 0.001$; $\eta^2 = 0.88$; $1 - \beta = 1.00$) and age ($F_{2,113} = 5.86$; $p = 0.004$; $\eta^2 = 0.09$; $1 - \beta = 0.87$) but not gender ($F_{1,113} = 3.56$; $p = 0.06$; $\eta^2 = 0.03$; $1 - \beta = 0.46$). There was also no significance in the interaction type of task \times age ($F_{2,113} = 0.38$; $p = 0.68$; $\eta^2 = 0.01$; $1 - \beta = 0.11$), type of task \times gender ($F_{1,113} = 2.23$; $p = 0.14$; $\eta^2 = 0.02$; $1 - \beta = 0.32$),

TABLE 1 | Descriptive statistics (*M* and *SD*) for the RT in the simple and complex tasks of the 119 subjects as a function of the eight positions of the sensor and the total (dominant hand).

		Total	1L	2L	3L	4L	5L	6L	7L	8L
SRT (ms)	M	632.03	613.71	603.19	644.17	713.36	695.51	645.44	572.06	585.38
	SD	97.38	99.21	100.76	124.44	158.51	163.74	123.58	93.093	84.764
CRT (ms)	M	840.68	792.10	840.76	838.69	871.54	854.22	855.60	827.00	862.08
	SD	110.79	129.83	137.2	134.77	152.87	142.43	138.96	132.09	121.21

SRT, simple reaction time; CRT, complex reaction time; L, light; M, mean; SD, standard deviation.

age \times gender ($F_{2,112} = 0.63$; $p = 0.54$; $\eta^2 = 0.01$; $1 - \beta = 0.15$), or type of task \times age \times gender ($F_{2,113} = 0.27$; $p = 0.76$; $\eta^2 = 0.01$; $1 - \beta = 0.09$).

Reaction Time and Physical Activity

Table 4 shows descriptive and normal analyses (Kolmogorov–Smirnov, $n > 50$; Shapiro–Wilk, $n < 50$) of reaction time (simple and complex) for each physical activity group.

ANOVA was performed for each RT measure, with differences observed between groups for SRT ($F_{2,116} = 4.43$; $p < 0.05$) and CRT ($F_{2,116} = 5.04$; $p < 0.01$). Bonferroni's statistic was applied to analyze the differences between the groups, observing differences between group 3 and group 1 in SRT ($p < 0.05$, $d = -0.68$, 95% CI $[-1.19, -0.17]$) and CRT ($p < 0.05$, $d = -0.63$, 95% CI $[-1.14, -0.12]$), as well as differences between group 3 and group 2 in CRT ($p < 0.01$, $d = -1.01$, 95% CI $[-1.56, -0.45]$) (**Figure 1**).

TABLE 2 | Descriptive statistics (M and SD) for the RT in the simple and complex tasks of the 119 subjects according to the six dozen trials.

		1D	2D	3D	4D	5D	6D
SRT (ms)	M	639.84	612.04	647.21	621.99	643.99	627.12
	SD	107.79	100.49	111.90	107.79	116.13	110.20
CRT (ms)	M	768.00	833.64	848.97	859.74	868.21	865.53
	SD	118.51	132.04	121.01	141.32	138.99	139.93

SRT, simple reaction time; CRT, complex reaction time; D, dozen; M, mean; SD, standard deviation.

TABLE 3 | Descriptive statistics (M and SD) for the RT in the simple and complex tasks according to gender and age.

	Age	10		11		12	
		Boys	Girls	Boys	Girls	Boys	Girls
SRT (ms)	M	642.58	668.22	591.15	632.62	551.51	625.00
	SD	116.58	73.23	75.91	115.75	55.76	86.66
CRT (ms)	M	874.58	868.81	800.74	832.97	767.80	816.83
	SD	131.42	94.51	93.13	123.77	53.80	99.88

SRT, simple reaction time; CRT, complex reaction time; M, mean; SD, standard deviation.

TABLE 4 | Descriptive statistics (M and SD) for the RT in the simple and complex tasks according to physical activity.

	M	SD	S	K	K-S	S-W
SRT group 1 (ms)	646.70	108.41	0.98	1.66	0.57	–
SRT group 2 (ms)	635.17	81.02	–0.24	–0.53	–	0.98
SRT group 3 (ms)	577.94	76.98	0.51	–0.12	–	0.92
CRT group 1 (ms)	847.12	123.83	0.82	1.03	0.30	–
CRT group 2 (ms)	865.08	95.32	–0.29	0.76	–	0.97
CRT group 3 (ms)	775.54	74.30	0.16	–0.58	–	0.96

SRT, simple reaction time; CRT, complex reaction time; M, mean; SD, standard deviation; S, skewness; K, kurtosis; K-S, Kolmogorov–Smirnov; S-W, Shapiro–Wilk.

Reaction Time, Physical Condition, and Attention

Table 5 shows the descriptive statistics for the variables of physical condition, selective attention, and RT, as well as the existing correlation with the RT in the two tasks.

Two regression analyses (successive steps) were performed, one for SRT and another for CRT, using as predictive variables the physical condition and measurements of the D2 attention test. The linearity assumptions were met in the relationship between predictor variables and criteria, homoscedasticity, and normal waste distribution. Durbin–Watson values were 2.05 and 1.93, so it can be assumed that the waste is independent, and the assumption of independence of the independent variables with respect to the dependent one is fulfilled (Pardo and Ruiz, 2005).

In the case of SRT, the regression model included two variables, velocity test ($\beta = 0.30$) and dynamometry (non-dominant) ($\beta = -0.23$). The following values were obtained for this model: $R = 0.43$; $R^2 = 0.19$; R^2 adjusted = 0.17; $F = 11.09$; $p < 0.001$. The tolerance (0.90) and variance inflation factor (1.11) values of the model were adequate.

In the case of CRT, the regression model included dynamometry (dominant) ($\beta = -0.40$), concentration (D2-CON) ($\beta = -0.40$), and VO2max ($\beta = -0.40$). The following values were obtained for this model: $R = 0.44$; $R^2 = 0.20$; R^2 adjusted = 0.17; $F = 7.92$; $p < 0.001$. The tolerance (0.93–0.97) and variance inflation factor (1.04–1.08) values of the model were adequate.

DISCUSSION

The objective of the present study was to analyze the relationships between RT with selective attention and concentration and also with weekly physical activity volume and physical fitness in a sample of children with ages from 10 to 12 years. Likewise, this investigation evaluated whether cognitive functioning and physical condition were adequate predictors of RT, both simple and complex. The results showed the relationship between RT and weekly physical activity volume, physical fitness, selective attention, and concentration. In general, physical fitness predicted RT scores. However, only cognitive functioning was a predictor of complex RT.

First, the amount of weekly physical activity has been related to simple and complex RTs. Those who did more hours of physical activity a week showed less RT on both tasks. These results are congruent with previous research that had pointed out these associations (Zwierko et al., 2014; Jain et al., 2015; Okubo et al., 2017; van de Water et al., 2017). Although the groups have not been divided according to the type of physical activity or sports performed, these results would support the idea that physical practice could be a useful activity to develop RT. When doing physical exercise, it is necessary to act effectively in a series of events, so this type of practice could have favored an increase in the capacity to act with greater speed and effectiveness in similar tasks (Nuri et al., 2013; van de Water et al., 2017; Lynall et al., 2018; Walton et al., 2018), transferring this ability to others

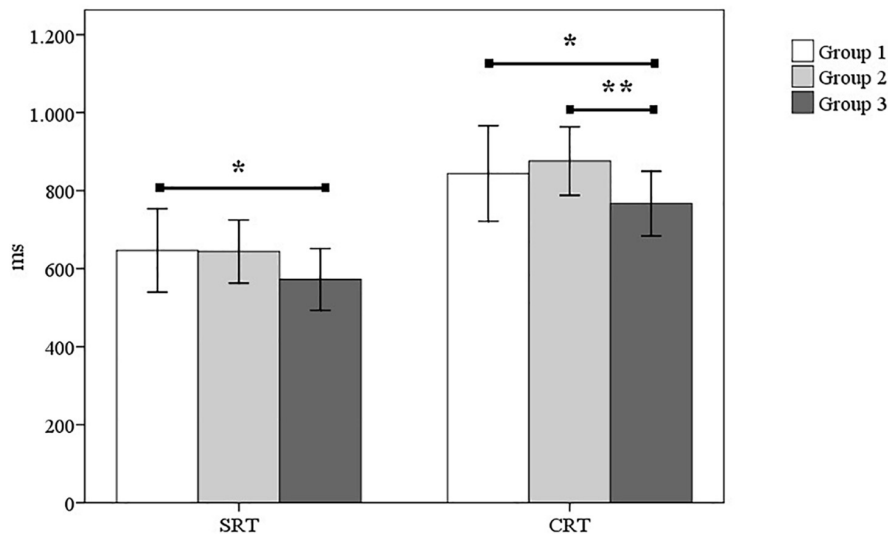


FIGURE 1 | Differences between groups for SRT and CRT. SRT, simple reaction time; CRT, complex reaction time. * $p < 0.05$; ** $p < 0.01$.

such as those evaluated in this work (Rabiner et al., 2010; Kirk et al., 2017).

Second, relations have been observed between the level of physical fitness, attentional capacity, and concentration with RT, which would approximate studies that had previously pointed out this phenomenon (Vaportzis et al., 2013; Jehu et al., 2015; Luque-Casado et al., 2016; Westfall et al., 2018). Being a correlational

study, it is not possible to determine causal effects, but according to the findings found in various investigations, there could be multiple links between the variables studied. Reloba-Martínez et al. (2017) highlighted that a high-intensity exercise program had positive effects on selective attention and fitness. Therefore, the combination of physical exercise and the development of cognitive functioning could be an appropriate formula to improve RT in people.

TABLE 5 | Descriptive statistics for the variables of physical condition, selective attention, and anthropometry and their correlation with the two RT tasks.

	<i>M</i>	<i>SD</i>	<i>S</i>	<i>K</i>	<i>K-S</i>	<i>TS</i>	<i>TC</i>
BMI	19.96	3.27	0.76	0.89	0.92	-0.05	-0.01
% fat mass	22.73	8.37	0.28	-0.13	0.68	-0.02	-0.01
Dyn_dom	16.49	3.64	0.25	-0.76	0.79	-0.28**	-0.36***
Dyn_non-dom	15.64	3.99	0.68	0.61	1.09	-0.29**	-0.32**
HJT	121.69	22.85	0.05	0.10	0.54	-0.31**	-0.25**
5 × 10	22.60	2.05	0.75	0.93	1.27	0.39***	0.21*
VO2max	44.16	4.26	0.34	-0.05	1.25	-0.27**	-0.26**
D2_TA	329.34	66.67	0.85	3.11	0.77	-0.09	-0.10
D2_TH	125.73	24.65	-0.47	0.31	0.63	-0.22*	-0.23**
D2_O	9.95	12.96	2.34	7.70	1.79**	-0.04	-0.05
D2_C	6.12	9.85	2.93	10.33	2.59***	0.01	0.10
D2_TET	307.71	56.13	-0.38	0.39	0.65	-0.19*	-0.25**
D2_CON	118.42	32.41	-0.82	1.30	0.89	-0.24**	-0.31**
D2_VAR	15.57	7.65	1.33	2.04	1.84**	-0.13	-0.06
SRT	632.03	97.38	0.77	1.55	0.63	-	-
CRT	840.68	110.79	0.59	0.95	0.92	-	-

M, mean; *SD*, standard deviation; *S*, skewness; *K*, kurtosis; *K-S*, Kolmogorov-Smirnov; *BMI*, body mass index; *Dyn_dom*, dynamometry (dominant); *Dyn_non-dom*, dynamometry (non-dominant); *HJT*, horizontal jump test (cm); *5 × 10*, speed test 5 × 10 m (s); *VO2max*, maximum oxygen consumption (ml/kg/min); *D*, *D2* test; *TA*, total number of attempts; *TH*, total number of hits; *O*, omissions; *C*, commissions; *TET*, total effectiveness in the test; *CON*, concentration index; *VAR*, variation index; *SRT*, simple reaction time; *CRT*, complex reaction time. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Specifically, linear regression analyses have shown that the simple RT has been predicted solely by physical condition measurements. However, the model generated for the complex RT has combined physical condition and attentional measures. Specifically, the dominant manual dynamometry, concentration, and maximum oxygen consumption have been included variables. This is consistent with previous studies that had highlighted a greater relationship between these measures in situations requiring greater cognitive control (Westfall et al., 2018). The complex RT requires selecting a response to different possibilities (Boisgontier et al., 2014), so the demands to respond effectively are greater. In this work, the RT has been evaluated by means of an oculo-manual coordination task using the FITLIGHT Trainer system, which suggests that a better physical condition and a greater capacity to concentrate could have influenced the developed behavior, as indicated by the data obtained.

It is interesting to note that the physical fitness measurements that predicted the values in complex RT were manual dynamometry and maximum oxygen consumption. Cardiorespiratory fitness has been widely documented as an ability linked to improved cognitive ability and improved performance on tasks requiring cognitive control (Kao et al., 2017; Westfall et al., 2018). However, the dominant manual dynamometry has been the strongest factor in the regression equation. This could have happened because of the type of task analyzed, which required

a quick and efficient motor action of the upper limbs in the face of the visual stimuli of the FITLIGHT Trainer test. Probably, the neuromuscular requirements intrinsic to the task itself could have conditioned the results found. This could indicate that it is important, when carrying out this type of studies, to take into account the type of activity analyzed, given that the nature of the activity could modulate the conclusions derived from it.

This paper presents a number of limitations. On the one hand, the analysis of oxygen consumption has been carried out indirectly, which is data with a certain margin of error. In future works, it would be interesting to use a type of direct gas analysis test in an incremental stress test to obtain more reliable data. On the other hand, the type of design used does not allow establishing causal relationships between the variables analyzed. It would be interesting to carry out longitudinal or quasi-experimental work to observe how the data evolve as a function of changes in the physical condition or in the cognitive functioning of the study sample. In any case, this research carries out an interesting analysis in which it has linked variables of cognitive functioning, physical practice, and physical condition with RT, providing data that allow us to delve deeper into this phenomenon and that increase empirical evidence of the internal factors that could condition RT in preadolescents.

The findings found in this study suggest that better development of attention and concentration, as well as physical condition, could help improve RT at these ages. This could contribute to improving efficiency in tasks that are important for the personal and social growth of children and adolescents. Therefore, it would be interesting to contribute to

its improvement when considering psychomotor development programs in this population.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of the University of Jaén, Spain (Ref. ABR.16/6). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

SB, IM, AH-M, VM-S, RR, and RJ-R participated in the study design and data collection, performed the statistical analyses, contributed to the interpretation of the results, wrote the manuscript, and approved the final manuscript. RR, AH-M, SB, and IM conceived the study and participated in its design and coordination. AH-M, VM-S, RR, RJ-R, SB, and IM contributed to the interpretation of the results, and reviewed and provided feedback to the manuscript. All authors made substantial contributions to the final manuscript.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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