Do sport-specific demands lead to sensory-motor changes?[1]

¿Las demandas específicas del deporte llevan a cambios sensoriomotores?

As demandas específicas do esporte levam a mudanças sensório motoras?

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[Research Article]

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Abstract

The study investigated how sport-specific environmental demands influence reaction time. Fifty-six women were divided into groups by age (Adults and Children) and sport-specific sensory-motor demands (Volleyball, Track and Field, Control). The Reaction Time task measured sensorimotor performance, prompting participants to quickly respond to visual stimuli by pressing the corresponding key. Reaction time was evaluated under two conditions with varying stimuli counts. Adults outperformed children in reaction time regardless of sport or age group. However, no significant differences were observed between sports within each age

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group. Additionally, sport experience did not predict sensorimotor performance according to regression analysis. These findings suggest that age-related changes significantly impact sensorimotor performance, while sport-specific environmental demands and experience have limited influence under non-specific conditions.

Keywords: maturation, reaction time, sport experience, training.

Resumen

Este estudio investigó cómo las demandas ambientales específicas del deporte influyen en el tiempo de reacción. Cincuenta y seis mujeres se dividieron en grupos por edad (Adultos y Niños) y demandas sensoriomotoras específicas del deporte (Voleibol, Atletismo, Control). La tarea de Tiempo de Reacción midió el rendimiento sensoriomotor, pidiendo a los participantes que respondieran rápidamente a estímulos visuales presionando la tecla correspondiente. Se evaluó el tiempo de reacción bajo dos condiciones que variaban en función del número de estímulos utilizados. En la comparación entre edades, los resultados indicaron superioridad de los adultos en relación con los niños. Sin embargo, no se observaron diferencias significativas entre los deportes dentro de cada grupo de edad. Además, la experiencia deportiva no predijo el rendimiento sensoriomotor según el análisis de regresión. Estos hallazgos sugieren que los cambios relacionados con la edad mejoran significativamente en el rendimiento sensoriomotor, mientras que las demandas ambientales específicas del deporte y la experiencia tienen una influencia limitada bajo condiciones no específicas.

Palabras clave: entrenamiento, experiencia deportiva, maduración, tiempo de reacción

Resumo

Este estudo investigou como as demandas ambientais específicas do esporte influenciam o tempo de reação. Cinquenta e seis mulheres foram divididas em grupos por idade (Adultos e Crianças) e demandas sensório motoras específicas do esporte (Voleibol, Atletismo, Controle). A tarefa de Tempo de Reação mediu o desempenho sensório motor, pedindo aos participantes que respondessem rapidamente a estímulos visuais pressionando a tecla correspondente. O tempo de reação foi avaliado sob duas condições que variavam o número de estímulos utilizados. Na comparação entre idades, os resultados indicaram superioridade dos adultos em relação às crianças. No entanto, não foram observadas diferenças significativas entre os esportes dentro de cada grupo etário. Além disso, a experiência esportiva não previu o desempenho sensório motor de acordo com a análise de regressão. Esses resultados sugerem que as mudanças relacionadas à idade impactam significativamente o desempenho sensório motor, enquanto as demandas ambientais específicas do esporte e a experiência têm influência limitada sob condições não específicas.

Palavras-chave: experiência esportiva, maturação, tempo de reação, treinamento, experiência.

Introduction

In sports where there is a need for rapid and accurate motor responses, the athlete's likelihood to perform a successful action is determined by the speed of the sensory-motor processes. This speed, in turn, depends on the reaction time (RT), a sensory-motor capacity that corresponds to the interval between stimulus presentation and response initiation (Marteniuk, 1976). The time required to execute an appropriate motor response is also conditioned upon sport-specific environmental demands, as the number of stimuli as well as their likelihood and predictability can affect the sensory-motor processing speed. For instance, in a 100-meter dash, the task demand consists of responding as quickly as possible to a single stimulus (i.e., shotgun), which is already known and expected. In volleyball, on the other hand, athletes have milliseconds to decide how to appropriately defend an opponent's attack, which may vary according to direction, height, and speed of the ball.

A number of studies have investigated RT across different sports (e.g., Bruzi et al., 2013; Castellar et al., 2019; Ferreira et al., 2017; Helm, Reiser, & Munzert, 2016; Kesoglou, & Smirniotou, 2019; Nuri et al., 2013; Papic et al., 2018; Yüksel, & Tunç, 2018), with the majority being focused on comparisons between athletes with more experience and novices in their respective sport (e.g. Balkó, Borysiuk, & Šimonek, 2016; Jackson, Warren, & Abernethy, 2006; Kioumourtzoglou et al., 2000; Lidor, Argov, & Daniel, 1998; Mori, Ohtani, & Imanaka, 2002; Mudric et al., 2020; Williams, & Walmsley, 2000). However, few studies investigated sensory-motor differences between sport modalities characterized by different environmental demands, and these found mixed results.

In the study by Nuri et al. (2013), for example, volleyball athletes showed lower choice RT compared to track and field athletes, whereas in the study by Bruzi et al. (2013), no differences in choice RT between track and field athletes, artistic gymnastics athletes, and sedentary individuals were found. Important considerations need to be taken into account when interpreting these results and analyzing possible future directions. First, the study by Nuri et al. (2013) did not include a control group, preventing a clear assessment of whether group differences in RT were due to sensory-motor changes that occurred as a function of training. Second, Nuri et al. (2013) and Bruzi et al. (2013) focused on adults and adolescents respectively, making it difficult to identify whether the observed sensory-motor changes were due to training, or were simply because of maturational processes. Finally, these studies did not investigate whether years of practice (here referred to as sport experience) predicted RT, which could offer interesting insights into the role played by training experience when it comes to RT.

Given the previously identified knowledge gaps, the present study investigated the effect of sport-specific environmental demands on the RT. We also investigated the relationship between sport experience and RT, controlling the effect of age. Considering sport-specific demands and maturational processes associated with age, we hypothesized that the training environment, age, and sport experience would lead to sport-related sensory-motor changes.

Methodology

Participants

Fifty-four females (Table 1) with normal or corrected-to-normal vision volunteered to participate in the study. Participants were assigned to groups according to age (i.e., Adults or Children) and sport-specific sensory-motor demands (i.e., Volleyball, Track and Field, Control). All participants provided written informed consent. For children, parental or legal guardian consent was obtained. The study was approved by the Federal University of Lavras institutional review board (CAE 20300813.0.0000.5148).

Table 1. Mean and standard deviation of age and sport experience of players

Groups	Age		Sport experience	
	mean	std	mean	std
Control adult (CA)	21.56	1.67		
Control children (CC)	10.22	0.67		
Track and Field adult (TA)	20.56	3.09	4.98	2.25
Track and Field children (TC)	9.11	1.17	0.83	1.03
Volleyball adult (VA)	27.67	3.57	10.75	5.58
Volleyball children (VC)	11.89	0.33	0.85	0.94

Source: created by the authors.

Apparatus and task

The Multi-Operational Apparatus for Reaction Time (MOART; Lafayette Instrument®; model 35.6000) with the PsymCon control (model 35.500) device was used to assess RT. For the purposes of the present study, only the L3, L4, R3, R4 and C5 keys were used, with the C5 key serving as the warning signal. The goal of the task was to respond as quickly as possible to a visual stimulus by releasing the key corresponding to the target stimulus (e.g., lifting the left index finger when the L4 key LED light was displayed).

RT was assessed under two conditions that varied according to the number of stimuli used. In the RT two condition (RT2), only two stimuli were used, and there was only one correct response associated with each stimulus. Specifically, under this condition, participants started the task with their left index finger on the L4 key and their right index finger on the R4 key. Thus, if the L4 key LED light was displayed, participants should lift their left index finger, whereas if the R4 key LED light was displayed they should lift their right index finger. The RT four condition (RT4), on the other hand, had four possible stimuli. Under this condition, participants started the task with their left middle and index fingers on the L3 and L4 keys, and their right middle and index fingers on the R3 and R4 keys respectively. Similar to the RT2 condition, for instance, if the L3 key LED light was displayed in the RT4 condition, participants should lift their left middle finger. The same logic applied to the other stimuli and respective response key. The following settings were adopted throughout the experiment: a) the warning signal was displayed in red color; b) visual stimuli were displayed in green color; c) the panel was set to the "release to respond" mode, meaning that the participants started the task with their fingers pressing the predetermined keys; d) visual stimuli were set to appear at a random interval between two and eight seconds; and e) the time limit to respond to the stimulus was set to three seconds with longer responses being classified as no response.

Procedures

Data collection was carried out in a separate room located at each participant's training facility or educational institution. Participants were assessed individually, and each data collection lasted approximately 10 minutes. Upon arrival, participants provided written consent and then were asked to sit comfortably in front of the MOART device. Prior to the task, we provided general instructions about the experimental procedures, such as the goal of the warning signal (i.e., a cue indicating that the participant should get ready to respond), the stimulus delay, keys that would be used throughout the experiment, and how to position each finger, and how to respond to the stimuli. Instructions related to task strategy (e.g., gaze behavior, or how hands should be positioned to achieve a faster response) were not provided.

The task was initiated once participants had appropriately positioned their fingers according to the testing condition (i.e., RT2 or RT4) and signaled that they were ready to start the task. One familiarization trial was allowed to ensure an accurate understanding of the task. All participants performed the RT2 condition first, followed by the RT4 condition. As with the study by Telles et al. (2013), five trials of each testing condition were carried out. After data collection, participants were debriefed and any questions regarding the study's goal were answered.

Statistical Analysis

Two-way ANOVAs (Age x Sports) were carried out to separately assess RT performance in RT2 and RT4 testing conditions. When applicable, the Bonferroni post hoc test was used to assess specific group differences. To test whether sport experience predicted RT, linear regressions were conducted for each testing condition (i.e., RT2 and RT4), controlling age and the interaction between age and sport category (i.e., track and field, and volleyball). The software R (cran.r-project.org) was used for all statistical analyses. Alpha level was set to 0.05, and partial eta squared (η_p^2) was reported as the effect size metric.

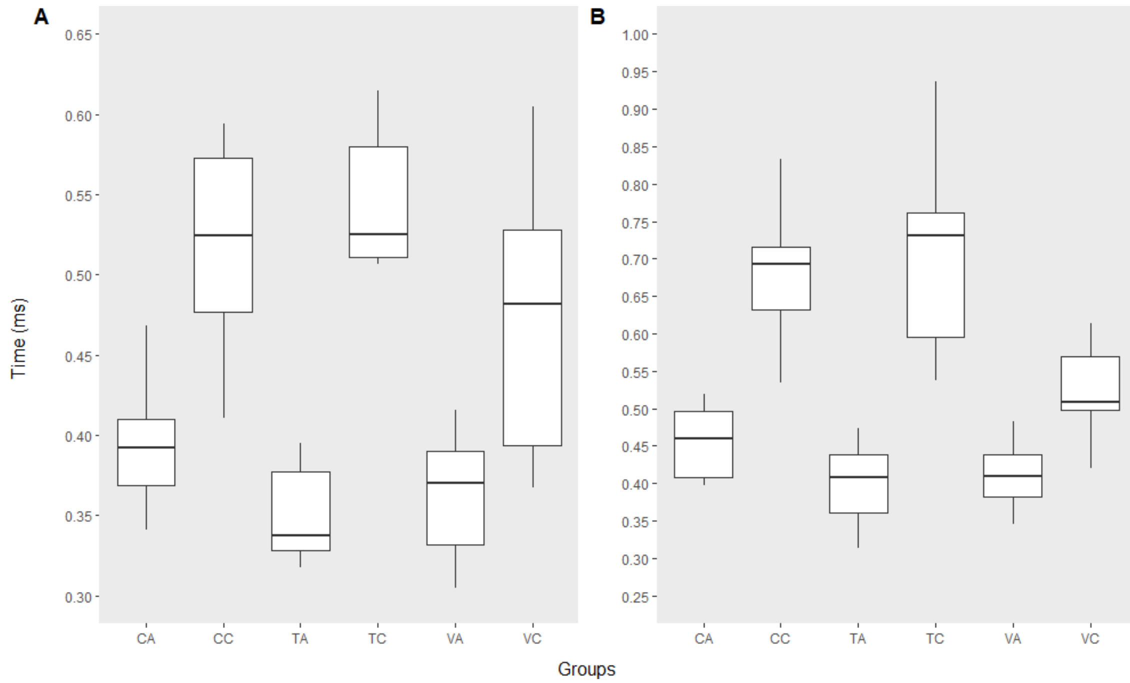
Results

Figure 1 shows RT for all six groups by testing condition. The Two-way ANOVA revealed a significant effect of age in the RT2 condition, F (1,54) = 58.60, p < .001, η_p^2 = 0.55. The Bonferroni post hoc test showed that both TA and VA performed better than the TC, VC and CC (*ps* < .007). The CA group performed better than the TC and CC groups (*ps* < .004), but not statistically different from the VC group (p = .064). No differences were found between adults (TA, VA and CA; *ps* > .05). There were also no differences between children (VC, TC, CC; *ps* > .05). The main effects of sport, F (2, 54) = .83, p = .438, η_p^2 = .03, and interactions between age and sport, F (2, 54) =.94, p = .396, η_p^2 = .03, were not significant.

For the RT4 testing condition, a main effect of age, F (1,54) = 53.93, p < .001, η_p^2 =.52, and sport, F (2,54) = 4.22, p = .021, η_p^2 =.15, was found. Specifically, the post hoc test revealed that TA, VA, and CA groups outperformed the TC and CC groups (p < .002), but did not differ from the VC group (p > .05). There were no significant interactions between age and sport, F (2,54) = 1.77, p = .181, η_p^2 =.06. Results of the regression model showed that sport experience did not significantly predict performance in the RT2 condition (β = 0.005, 95% *CI* [-0.02, 0.03], p = 0.695) and in the RT4 condition (β = -0.02, 95% *CI* [-0.06, 0.01], p = 0.168) for either sport.

Figure 1.

Mean RT values per group in testing conditions RT2 (A) and RT4 (B). Errorbars indicate mean standard errors.



Source: created by the authors.

Discussion

The present study investigated the effects of sport-specific environmental demands on the RT. Specifically, we sought to understand the effects of different environmental demands on RT in athletes from different sports and age groups. We hypothesized that the training environment, age, and sport experience would lead to sport-related sensory-motor changes.

Studies have shown divergent results. For example, Nuri et al. (2013) compared the performance of volleyball and track and field athletes, aged between 20 and 24 years, and found that athletes had better performances in domains related to their respective sports. The same did not occur in the study by Bruzi et al. (2013), in which adolescent basketball players did not obtain superiority compared to gymnastics and sedentary athletes in RT tasks. The results found in the present study provide an additional understanding of the phenomenon, promoting a better understanding of the effects of environmental demands, sports experience, and age on RT.

Comparisons between children and adults in the present study found partial support in neurophysiological changes caused by maturational processes. According to Connolly (1970), such changes cause structural alterations in the Central Nervous System, and this leads to gains in the level of functionality. The mechanisms underlying RT improved, and therefore individual's information processing capacity was enhanced. Thus, because children have a more rudimentary sensorimotor system compared to adults (Connolly, 1977; Thomas, 1980), the former have a higher latency in the motor response. Therefore, the superior performance compared to children in this study can be attributed to varying capacities in information processing due to neurophysiological changes.

However, the non-superiority of the VA, TA, and CA groups in relation to the VC indicates that the functional gains of maturation are not the only explanatory factors for the results of this study. According to Connolly (1970), throughout the acquisition of sport experience, the mechanisms involved in the motor response become more efficient, shortening steps, and discriminating irrelevant information during sensorimotor processes. This occurs due to cognitive changes that improve the ability to process information. Such changes suggest that the constant need to make quick and accurate decisions in Volleyball would cause volleyball players to develop the ability to identify relevant environmental information (Murphy, Jackson, & Williams, 2019, for a review) and, based on this, trace efficient strategies (e.g. use of peripheral vision in the search for the stimulus). In this sense, optimized information processing would result in reduced reaction time and increased efficiency of motor responses. Thus, the non-superiority of adults in relation to the VC could indicate a sensorimotor improvement arising from practice, according to the hypothesis of the present study. However, further investigation is needed due to the absence of superiority among groups practicing Volleyball compared to their age peers. Also, the non-significance of sport experience as a predictor of sensory-motor performance rejects an exclusively environmental route of explanation.

An explanation for the non-difference between sports groups with the same age group could be attributed to the lack of ecological validity and complexity of the experimental task. The task does not reflect the environmental demands of sports and has few components. This allowed for a high-level of proficiency to be achieved, causing an *artificial* leveling of performance between groups. Thus, the use of a task with low complexity and ecological validity may not have adequately captured the effects of the specificity of the practice on sensorimotor performance (Abernethy, Thomas, & Thomas, 1993, Dicks, Button, & Davids, 2010).

Researchers in this domain have indicated that tests with high ecological validity should be used to assess sports phenomena (e.g., Abernethy, Thomas, & Thomas, 1993; Roca, & Williams, 2016; Williams, & Ericsson, 2005). This is because tasks with greater ecological validity are more accurate for predicting sports performance. This suggests that, to enhance the validity of the results, tests capturing relevant information of the sport modality under study are recommended. Specifically, studies using high ecological validity compared the sensorimotor performance of beginners and experienced players (e.g. Mann, Abernethy, & Farrow, 2010). However, comparing sports with different sensorimotor demands in tests with high ecological validity requires further investigation.

The results of the present study led to conclude that age-related changes contribute to the improvement of sensorimotor performance. However, the non-superiority of the adult groups in relation to the VC suggests that such changes are not the only explanatory factor. Furthermore, the sport-specific environmental demands and sport experience did not affect sensory motor performance under conditions with low ecological validity. Future studies aiming to understand the effect of sport-specific demands and their interaction with age and sport experience should explore this phenomenon using tasks more representative of the nature of the sports.

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