

Correlations between Impulsivity and Technical Performance in Handball Female Athletes

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A complex and dynamic environment where impulsivity probably interferes in the human behavior is the sport context. The aim of this exploratory study was to investigate the possible relationship between impulsivity and technical performance in handball athletes. Eleven junior female athletes on a handball team were submitted to a neuropsychological assessment of impulsivity using Conner's CPT-II and the Iowa Gambling Task. In 11 matches, participants' handball performance was analyzed. We adopted the resampling statistical approach to correlate the measures of technical performance with the neuropsychological measures. IGT net score was positively correlated with technical faults. Omission errors on the CPT-II were positively correlated with the number of fouls suffered, the number of fouls committed, and the number of offensive fouls. Commission errors on the CPT-II were negatively correlated with rebounds with defense ball possession. Our results support the idea of relationships between impulsivity and technical performance in specific match situations.

Keywords: Impulsivity, Sports, Handball, Motor Behavior, Attention, Decision Making, Response Inhibition

Introduction

Impulsivity is a behavioral pattern characterized by several types of manifestations. For instance, Barratt (Patton, Stanford, & Barrat, 1995) proposed the existence of three classes of impulsivity: motor (acting without thinking), attentional (lack of focus on the task at hand), and non-planning (focus on the present without accounting for the consequences of the future outcomes).

The impulsive behavior is a core symptom in a large number of psychiatric disorders but, nonetheless, there is also a growing interest in the role of impulsivity among healthy populations engaging in different activities (Stanford, Mathias, Dougherty, Lake, Anderson, & Patton, 2009). For example, a complex and dynamic environment where impulsiveness probably interferes in the human behavior is the sportive context. Previous research in this area has focused on demonstrating the relationship between impulsivity and the involvement in particular types of sports. Svebak and Kerr (1989), for example, compared the impulsiveness of athletes involved in sports defined as "endurance sports" (i.e., those involving sustained activity) and "explosive sports" (i.e., those involve short, intense bursts of activity). They found that athletes who engaged in explosive sports (e.g., football) scored higher on impulsivity measures than endurance participants (e.g., marathon runners).

Impulsivity may be an important factor in motor performance interference in open-skill sports (e.g., soccer, basketball and handball). Due to constant changes in the environment (e.g., alterations in opponents positioning), the player is forced to inhibit pre-planned responses, anticipate actions and coordinate corporal segments based on the complex and dynamic flow of sensorial information. Previous studies using motor laboratory

tasks have shown that motor control is affected by the degree of the subject's impulsivity (Enticott, Ogloff, & Bradshaw, 2006; Lemke, Fischer, Wendorff, Fritzer, Rupp, & Tetzlaff, 2005). For instance, healthy individuals with higher impulsivity scores present shorter relative time to achieve the peak velocity than the low-impulsives in manual aiming movements (Lemke et al., 2005). In addition, high-impulsive subjects tend to inhibit their responses at a slower pace than low-impulsive subjects (Lijffit, Bekker, Quik, Bakker, Kenemans, & Verbaten, 2004). High-impulsive subjects also present higher reaction time than low-impulsives in conditions of low compatibility stimulus-response (Expósito & AndrésPueyo, 1997) and are less accurate than low-impulsives in tapping at a specified rate (Barrat, 1981). In spite of some controversial findings (cf. Dickman, 1993), the general pattern over the course of these studies has indicated that high-impulsive subjects are faster in their responses but less accurate than their less impulsive counterparts (Lage, Malloy-Diniz, Neves, Moraes, & Corrêa, in press).

Although generally viewed as counterproductive (Stanford et al., 2009), it is possible that impulsivity had a positive role on motor behavior in some specific circumstances. This may be true in cases in which there is limited time available to: 1) recognize the opponent's action; 2) process a decision; and 3) organize the motor system to initiate a response. In such situations, it is probable that some degree of impulsivity helps the player to achieve his/her goal successfully. An explanation for this hypothesis might be based on the concept of functional impulsivity characterized by a tendency or ability to think, act and speak rapidly (Dickman, 1990, Reeve, 2007). Recently, Lage et al. (in press) found that in situations in which the temporal and spatial demands to the motor system were high, the impulsivity had a functional, adaptive effect on manual motor control.

Although several evidences suggest an influence of impulsivity on motor control, to our knowledge, there are no studies investigating this relation in the context of competitive sports. Therefore, we aimed to investigate the relationships between different impulsivity dimensions and technical performance in an open-skill sport. Handball was chosen because it is a fast and dynamic game that is played in a confined area where a high degree of temporal and spatial pressure is involved. The very intense physical contact among players often creates moments of forceful behaviors, and the close proximity of coaches, officials and spectators to the court may represent an increased psychological demand.

Although our approach was mainly exploratory, on the basis of previous evidence found in laboratory studies, an association between impulsivity dimensions and technical performance was predicted. In match situations in which both speed and accuracy are categorically involved (e.g., when a shot on goal is taken), motor impulsivity should be a factor of possible interference. In match conditions that require high decisional demand (e.g., when the player holds the ball and has a second or two to decide what to do next), non-planning impulsivity may be related to the quality of motor response. In situations in which the attentional demands are high (e.g., a direct confrontation with the opponent), attentional impulsivity might be related to the player's level of success.

Methods

Participants

Twenty-two junior female athletes (between 17 and 18 years of age; mean age = 17.45 ± 0.5 years) from a three-time state champion handball team were invited to participate in this study. All of them were court players. Seven players decided to not participate, resulting in a sample of fifteen athletes. On average, participants had 6 ± 1.8 years of handballs experience. The local ethics review committee approved the study protocol. All participants and their parents (only for the 17-year-old participants) signed informed consent forms before participating in this study.

Instruments

The neuropsychological assessment has been described elsewhere (see in Malloy-Diniz et al., 2007). Briefly, we used *Conner's Continuous Performance Task* (CPT-II; omission and commission errors as measures of attentional and motor impulsivity) and the *Iowa Gambling Task* (IGT; the net score was used as a measure of non-planning, decision-making, -related impulsivity). Unlike CPT-II scores, high scores on the IGT indicate a low level of impulsivity (Lage, Malloy-Diniz, Matos, Bastos, Abrantes, & Corrêa, 2010).

Handball Technical Performance Evaluation. To scrutinize the technical performance of the 15 court players, some parameters of a handball scout were used (Vieira, Greco, & Chagas, 1990). The performance parameters investigated were divided into technical faults, throwing and other measures.

The technical faults of each player were analyzed based on the number of times any of the following occurred: 1) passing error; 2) reception error; 3) touching the ball with the foot; 4) double dribble; 5) loss of ball possession; 6) entering the goal area; 7) carrying the ball for more than three steps; 8) holding the ball for more than three seconds; and 9) offensive foul. The technical performance related to the throwing was ana-

lyzed through the number of: 1) shots scored (goals); 2) shots missed (ball was out of the court or ball hit the goalpost or crossbar); 3) shots caught by the goalkeeper; 4) shots that resulted in rebounds with defense ball possession (goalkeeper rebounded and ball possession was returned to the defense); 5) shots that resulted in rebounds with attack ball possession (goalkeeper rebounded and the ball possession stayed with the attack); 6) shots blocked with defense ball possession (shot blocked and the defense stayed with the ball possession); and 7) shots blocked with attack ball possession (shot blocked and the ball returned to the attack players). Other performance measures analyzed were: 1) gaining possession of the ball ("stolen" the ball of opponent); 2) passive play; 3) fouls committed; and 4) fouls suffered. In each match, all of these technical aspects were analyzed for each player throughout the handball scout.

Procedure

Eleven matches in the regional championship (during the first semester of 2007) were analyzed. During the same period (first semester of 2007, before the championship), the CPT-II and IGT were administered to all players. Two trained physical education professionals were responsible for watching and filling the scouts during the matches. A third experimenter filmed the matches in case of doubt in the posterior analyses. Two trained neuropsychologists administered the neuropsychological tests (tests were applied individually in a quiet room. See detailed procedures in Malloy-Diniz, 2007). The order of CPT-II and IGT application was randomized among participants. The entire procedure was blinded since the neuropsychologists did not watch the matches and the physical education professionals did not have access to neuropsychological results.

Analyses

Before the contest, we conducted a pilot study that consisted of the analysis of three handball matches. The purpose of the study was to analyze the coefficient of concordance among the three physical education professionals. Kendall's *W* test indicated a significant degree of concordance ($W = .9193$, $p < .0001$) on the filling of the scout.

After the championship, the match analysis showed that three players did not play any of the 11 matches. One athlete played for only a very short time during matches (mean of 11.25 minutes). Thus, we decide to exclude this player from the final analysis. Therefore, the final sample was composed of 11 athletes who played a mean of 7.58 (SD = 2.7) matches with a mean time on court of 33.24 (SD = 10.6) minutes.

Due to the small sample size of this study we adopted the resampling statistical approach (Stergiou, 2004), more specifically, a correlation with random data permutation (see the procedures in Edginton & Onghena, 2007: p.178). We correlated the measures of technical performance (the mean for each player during the 11 matches) with the neuropsychological measures (scores obtained in each test). The number of resamples of the original data was equal to 1000, and the level of significance adopted in all analyses was .05. The software used was RT4win (Edginton & Onghena, 2007).

Results

Neuropsychological data of each player are presented in Ta-

ble 1.

Technical performance data of each player are presented in Table 2. The technical fault of “holding the ball for more than three seconds” was not analyzed because this variable was constant (zero) during all matches for all players.

Correlations between Technical Faults and Neuropsychological Measures

The correlations between technical faults and neuropsychological measures are shown in Table 3. A significant nega-

Table 1.
Neuropsychological data of each player.

Neuropsychological data	Players										
	1	2	3	4	5	6	7	8	9	10	11
OE	12	7	13	12	11	5	17	16	15	6	8
COE	35	7	21	11	18	21	11	21	26	3	17
Net Score	-2	46	-20	4	19	12	10	19	-14	-20	0

Note: Neuropsychological measures: OE = omission errors on the CPT-II; COE = commission errors on the CPT-II; Net Score = total score on the IGT.

Table 2.
Technical performance data of each player.

Performance measures	Players										
	1	2	3	4	5	6	7	8	9	10	11
Matches	4	11	10	5	4	11	4	8	10	10	6
MTC	16.3	41.2	46.3	40.5	34.7	42.2	21.6	30.6	38.3	36.2	40.1
PE	4	2	13	15	4	12	19	0	8	7	3
RE	1	1	4	3	3	1	10	2	3	4	0
TBF	0	0	2	1	1	1	3	0	1	2	2
DD	0	0	3	1	2	0	1	0	0	0	0
LBP	0	1	0	4	0	1	1	0	0	0	0
EGA	0	0	3	1	0	1	1	1	2	0	0
CBTS	0	0	10	0	0	2	0	1	3	0	0
OF	0	0	1	0	0	0	1	0	0	0	0
SS	8	2	45	65	16	12	54	4	13	35	6
SM	4	0	9	12	1	2	15	0	4	5	0
SC	3	2	14	16	13	6	19	1	6	9	2
SRDP	0	0	0	0	0	0	5	0	0	0	0
SRAP	0	1	0	1	0	0	0	0	0	0	0
SBDP	1	0	0	0	0	0	0	0	1	1	0
SBAP	0	0	1	0	0	0	0	0	0	0	1
GBP	9	2	18	6	6	7	26	1	6	20	4
PASSIV	0	0	0	0	1	0	0	0	0	0	0
FC	17	6	60	35	13	7	42	2	17	28	6
FS	24	7	52	19	24	7	37	6	16	27	9

Note: Number of matches played = Matches. Mean time on court (minutes) = MTC. The technical performance measures: passing errors (PE); reception errors (RE); touching the ball with the foot (TBF); double dribble (DD); loss of ball possession (LBP); enter the goal area (EGA); carrying the ball for more than three steps (CBTS); offensive foul (OF); shots scored (SS); shots missed (SM); shots caught by the goalkeeper (SC); shots that result in rebounds with defense ball possession (SRDP); shots that result in rebounds with attack ball possession (SRAP); shots blocked with defense ball possession (SBDP); shots blocked with attack ball possession (SBAP); gaining possession of the ball (GPB); passive play (PASSIV); fouls committed (FC); and (4) fouls suffered (FS).

Table 3.
Correlations between technical faults and neuropsychological measures.

Impulsivity measures	Technical faults								
		PE	RE	TBF	DD	LBP	EGA	CBTS	OF
OE	<i>r</i> =	-.44	.03	-.47	-.29	.01	.14	.20	-.61*
	<i>p</i> =	.18	.92	.14	.38	.95	.65	.57	.04
COE	<i>r</i> =	-.13	.07	-.37	-.50	.38	-.39	-.55	-.18
	<i>p</i> =	.69	.83	.24	.13	.25	.22	.08	.53
Net Score	<i>r</i> =	.11	.28	.04	.28	-.34	.63*	.69*	.64*
	<i>p</i> =	.74	.36	.90	.37	.32	.02	.02	.02

Note: *significant correlation ($p \leq .05$). The technical performance measures: passing errors (PE); reception errors (RE); touching the ball with the foot (TBF); double dribble (DD); loss of ball possession (LBP); enter the goal area (EGA); carrying the ball for more than three steps (CBTS); offensive foul (OF). Neuropsychological measures: omission errors on CPT-II (OE); commission errors on CPT-II (COE); total score from IGT (Netscore). The *r* values refer to original data and the *p* values refer to the 1,000 resampling.

tive correlation ($r = -.61$, $p = .04$) was found between offensive fouls (OF) and omission errors (OE) on the CPT-II. In other words, the number of fouls made in attack was inversely correlated with the players' level of attentional impulsivity. Furthermore a positive correlation was found between the IGT net score and the following foul measures: 1) entering the goal area (EGA) ($r = .63$, $p = .02$); 2) carrying the ball for more than three steps (CBTS) ($r = .69$, $p = .02$); and 3) offensive foul (OF) ($r = .64$, $p = .02$). Since high IGT net scores indicate low levels of non-planning impulsivity, a lower level of this kind of impulsivity was related to a higher number of offensive fouls. Other correlations were not significant (Table 3).

Correlations between Throwing Performance and Neuropsychological Measures

The analysis of technical performance related to the throwing and neuropsychological measures (Table 4) showed a significant positive correlation between shots that resulted in rebounds with defense ball possession (SRDP) and commission errors (COE) on CPT-II ($r = .67$, $p = .03$). This finding shows that higher levels of motor impulsivity were related to a higher number of balls defended by the goalkeeper that resulted in rebounds with defense ball possession. Other correlations were not significant (Table 4).

Correlations between Other Performance Measures and Neuropsychological Measures

Omission error scores on the CPT-II were negatively correlated with the following performance measures: 1) gaining possession of the ball (GPB) ($r = -.63$, $p = .03$); 2) fouls committed (FC) ($r = -.63$, $p = .04$); and 3) fouls suffered (FS) ($r = -.63$, $p = .02$). In other words, higher levels of attentional impulsivity were related to fewer fouls (committed or suffered) and fewer "stolen" balls (represented by the gaining possession of the ball measure). Other correlations were not significant (Table 5).

Discussion

The aim of this exploratory study was to investigate the possible relationships between impulsivity dimensions and technical performance on an open-skill sport. To the best of our knowledge, this is the first study to investigate the possible

relationship between impulsivity and this specific facet of sports—the technical skills. Three types of results were identified: non-planning impulsivity was positively correlated with measures related to technical faults; attentional impulsivity was positively correlated with measures related to fouls; motor impulsivity was negatively correlated with a measure of throwing: rebounds with defense ball possession. The magnitude of all significant correlations was moderate (0.61 - 0.69).

Non-planning impulsivity, as measured on the IGT, was positively correlated with the following measures of technical faults: 1) entering the goal area; 2) carrying the ball for more than three steps; and 3) offensive foul measures. At first sight, these findings seem paradoxical because low non-planning impulsivity was correlated with a higher number of technical faults. It has been shown that non-planning impulsivity has a dysfunctional role in decision-making so that impulsive individuals make risky decisions. In doing so, they choose immediate rewards despite potential long-term negative consequences (Möller, Barrat, Dougherty, Schmitz, & Swann, 2001). Decision-making consists of multiple operations, including option evaluation, actions and outcome monitoring. These operations involve slow, conscious and effortful reflections about possible consequences (Bechara & Van der Linden, 2005). This is a remarkable feature in open-skill sports characterized by a high level of uncertainty that forces the player to use complex cognitive skills under temporal pressure (Ripoll, Kerlirzin, Stein, & Reine, 1995). Hence, it is possible that players with low non-planning impulsivity emphasize the accuracy of motor responses, thereby causing a temporal cost in situations in which the speed of information processing is an essential feature. In other words, players with low non-planning impulsivity would have decreased technical performance in match situations in which they needed to think and respond quickly.

This assumption is corroborated by Dickman and Meyer (1988), who found a relationship between impulsivity and optimality of performance. High-impulsive subjects exhibited decreased performance when accuracy was rewarded more than speed, whereas low-impulsive subjects presented a disadvantage when speed was rewarded more than accuracy. In this sense, individuals at both extremes of the impulsivity continuum are at a disadvantage under specific circumstances. However, further studies are needed to confirm that functional impulsivity has a positive role in open-skill sports in which complex decision-making under temporal and/or spatial pressure is

Table 4.
Correlations between performance in throwing and neuropsychological measures.

Impulsivity measures	Measures of performance in throwing							
	SS	SM	SC	SRDP	SRAP	SBDP	SBAP	
OE	<i>r</i> =	-.31	-.57	-.33	.12	-.49	.18	-.33
	<i>p</i> =	.38	.07	.32	.77	.09	.55	.36
COE	<i>r</i> =	-.14	-.08	-.28	.67*	.13	.22	-.37
	<i>p</i> =	.67	.81	.38	.03	.80	.50	.16
Net Score	<i>r</i> =	-.08	-.04	-.02	-.26	.13	-.14	.72
	<i>p</i> =	.81	.98	.92	.35	.53	.65	.08

Note: *significant correlation ($p \leq .05$). Technical performance measures: 1) shots scored (SS); 2) shots missed (SM); 3) shots caught by the goalkeeper (SC); 4) shots that result in rebounds with defense ball possession (SRDP); 5) shots that result in rebounds with attack ball possession (SRAP); 6) shots blocked with defense ball possession (SBDP); and 7) shots blocked with attack ball possession (SBAP). Neuropsychological measures: omission errors on the CPT-II (OE); commission errors on the CPT-II (COE); total score from IGT (net score). The *r* values refer to original data and the *p* values refer to the 1000 resampling.

Table 5.
Correlations between performance measures and neuropsychological measures.

Impulsivity measures	Other performance measures				
	GPB	PAS	FC	FS	
OE	<i>r</i> =	-.63*	.28	-.63*	-.62*
	<i>p</i> =	.03	.41	.04	.02
COE	<i>r</i> =	-.11	-.13	-.29	-.52
	<i>p</i> =	.73	.66	.37	.10
Net Score	<i>r</i> =	.18	.05	.28	.27
	<i>p</i> =	.59	.84	.39	.41

Note: *significant correlation ($p \leq .05$). Technical performance measures: 1) gaining possession of the ball (GPB); 2) passive play (PASSIV); 3) fouls committed (FC); and 4) fouls suffered (FS). Neuropsychological measures: OE = omission errors on the CPT-II; COE = commission errors on the CPT-II; net score = total score on the IGT. The *r* values refer to original data and the *p* values refer to the 1000 resampling.

required. One possible way to investigate this directly is to administer the Functional Impulsivity Scale (Dickman, 1990) to the players.

The attentional impulsivity analyses revealed a negative correlation between the omission errors on the CPT-II and several situations in which the player had some kind of contact with the opponent. High numbers of fouls suffered (committed or offensive) were related to low attentional impulsivity. One could say that these findings also seem intuitively paradoxical. However, because a person with a high level of attentional impulsivity presents an inability to focus on a task (Malloy-Diniz et al., 2007)—perhaps resulting from a greater susceptibility to changes in arousal (Stanford et al., 2009)—it is possible that he or she has more restricted participation during matches due to his or her higher distractibility. This type of behavior would explain the inverse correlation found between attentional impulsivity and fouls, as highly impulsive players are those less involved in contact situations. Taking into account the limitations of correlational studies and the lack of previous research with similar characteristics, this assumption should be viewed cautiously.

Attentional impulsivity also showed a negative correlation with the gaining possession of the ball measure. Here, the results seem intuitive: low levels of attentional impulsivity were related to higher numbers of “stolen” balls. In this case, players

who were more focused on their tasks probably had more success in this technical fundament.

A positive correlation was found between rebounds with defense ball possession and motor impulsivity. Here, it is possible that 1) a trend to specify stereotyped motor responses or 2) a propensity to respond rapidly, thereby emphasizing the speed to the detriment had some influence in this finding. Spinella (2005) found that motor impulsivity is related to deficits in self-inhibition. It is possible that an inability to inhibit pre-potent motor responses, observed in high-impulsive subjects (Möller et al., 2001), creates more a stereotyped pattern of throwing that facilitates the action of the goalkeepers. Another explanation is related to the speed-accuracy trade-off phenomenon (Schmidt & Lee, 2005). This phenomenon is associated to the human tendency to decrease the accuracy of a motor response when its speed is increased. Literature about impulsivity shows that high-impulsive subjects are faster in their responses but less accurate than their less impulsive counterparts (Lage et al., in press). Therefore, it is possible that high-impulsive players presented faster throwing, but with a decreased accuracy when compared to the low-impulsives, characteristic that facilitates the action of the goalkeepers.

In short, this study is the first to produce evidence of a relationship between impulsivity and technical performance in an open-skill sport. As a consequence, this study may open a

promising way of investigating the impact of impulsivity in a specific context of sportive performance. However, it is important to remember that the need for a resampling statistical approach only allowed us to draw assumptions about the sample at hand, rather than about the population as a whole (Stergiou, 2004). Furthermore, the descriptive analysis does not prove any causal relationship between impulsivity and performance. Due to these limitations, our results should be interpreted with caution. Further studies with a sample size that permits the separation of high impulsivity athletes from low impulsivity athletes are needed in order to compare the technical performance between the two groups. Similar investigations with other open-skill sports are also suggested.

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