European Journal of Sport Science
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tejs20

Tactical proficiency among table tennis players with and without intellectual disabilities

Debbie Van biesen [a] , Jennifer Mactavish [b] & Yves Vanlandewijck [a]
[a] Department of Rehabilitation Sciences , KU Leuven , Leuven , Belgium
[b] School of Graduate Studies , Ryerson University , Toronto , ON , Canada
Published online: 07 Aug 2013.

To cite this article: Debbie Van biesen , Jennifer Mactavish & Yves Vanlandewijck , European Journal of Sport Science (2013): Tactical proficiency among table tennis players with and without intellectual disabilities, European Journal of Sport Science, DOI: 10.1080/17461391.2013.825645

To link to this article: http://dx.doi.org/10.1080/17461391.2013.825645

European Journal of Sport Science, 2013
http://dx.doi.org/10.1080/17461391.2013.825645

Routledge
Taylor & Francis Group

ORIGINAL ARTICLE

Tactical proficiency among table tennis players with and without intellectual disabilities

DEBBIE VAN BIESEN[1], JENNIFER MACTAVISH[2], & YVES VANLANDEWIJCK[1]

[1]*Department of Rehabilitation Sciences, KU Leuven, Leuven, Belgium,* [2]*School of Graduate Studies, Ryerson University, Toronto, ON, Canada*

Abstract
The effect of intellectual impairment on sports performance has received limited attention by researchers. As a contribution to closing this gap, the purpose of the present investigation was to examine the differences in tactical proficiency between table tennis players with and without intellectual disabilities (ID). These groups were matched for training-volume and experience and consisted of 41 male (age = 27 ± 8) and 30 female (age = 28 ± 8) elite players with ID and a reference group of 12 male (age = 24 ± 12) and 5 female (age = 20 ± 9) players without ID. In two different test settings – one a World Championship and the other a training camp – the players in each group performed 60 semi-standardised rallies against the same opponent. Players were told that 12 sets of five identical services would be delivered, and their goal was to return the service with the intention of 'winning the point'. The test results were validated for this study, to compute tactical proficiency scores (maximal score of eight points) for each player. A two-way Analysis of Variance (ANOVA) revealed significantly lower proficiency scores for players with ID than for those without ID. Repeated-measures ANOVA revealed that within each series of five rallies, starting with identical services, all participants were able to significantly improve their tactical proficiency gradually, but players without ID scored 4.3 ± 0.5 from the first ball on, and while athletes with ID only 3.3 ± 0.7 after five balls. The results of this study indicate that ID is associated with decreased tactical proficiency in table tennis.

Keywords: *Intellectual disability, tactical proficiency, sport intelligence, table tennis, elite sport*

Introduction

In the present study, the effects of intellectual impairment in sport performance are examined. Intellectual impairment is used throughout the manuscript to denote deficits in intellectual functioning; which is defined as the general mental operations required to understand and constructively integrate the various mental functions, including all cognitive functions and their development over the life span. 'Intellectual disability' (ID) is used when referring to individuals. ID, as defined by the American Association on Intellectual and Developmental Disabilities (AAIDD, 2010), is characterised by significant deficits in intellectual functioning (IQ ≤ 75) and also adaptive behaviours and is manifested before the age of 18.

Controversy concerning the exact nature of the relation between intellectual functioning and sport performance is replete in the literature. In a literature review, Dexter (1999) concluded that correlations between sport performance and academic ability are weak. Dexter (1999) considered academic ability as a parameter of intellectual functioning and defined it as learning and acquisition of scholastic types of knowledge, which are typically reflected in academic performance or school results. Some studies of basketball have found a small but positive relationship between academic ability and sport performance (French & Thomas, 1987; McPherson & Thomas, 1989; Starkes, 1987); while others, in athletics (Coackly, 1993), for example, have found none. In studies of gymnastics and swimming, negative findings have been reported (Dexter, 1999). One possible explanation for this lack of consistency could be attributable to the conceptual breadth of intelligence and sport performance. To

Correspondence: Debbie Van Biesen, Department of Rehabilitation Sciences, KU Leuven, Tervuursevest 101, 3001 Leuven, Belgium. E-mail: debbie.vanbiesen@faber.kuleuven.be

address this concern and facilitate understanding of the link between these concepts requires closer examination of the distinct and measurable components that comprise these constructs.

Among the more recent studies that have attempted to isolate specific aspects of intelligence, Anderson and Miller's (2002) work is helpful in illustrating a correlation between measures of speed of processing (e.g. reaction-time and inspection-time) and intelligence test performance (e.g. Raven's Standard Progressive Matrices) concluding that slower speed of processing occurs in persons with ID.

Di Blasi, Elia, Buono, Ramakers, and Di Nuovo (2007) observed basic cognitive functions of persons with ID and found delayed and slow acquisition of information, limited plasticity in visuo-spatial organisation and lower perceptual efficiency in information-processing with increased complexity, speed and duration. This supported their view of ID as an information-processing deficiency.

These studies also point to different components that contribute to intelligence and suggest that some elements of intelligence are less important (e.g. knowledge, anticipation, reaction-time, information-processing, visual perception, memory and attention) (Haywood & Getchell, 2009; Thomas, Gallagher, & Thomas, 2001; Williams & Reilly, 2000).

In looking for a relevant measure of sport performance, tactical proficiency (TAP) was isolated because it is largely dependent on cognitive processes such as decision-making, pattern recognition and space-perception (Raab, Masters, & Maxwell, 2005). With this focus, the present article builds on Van Biesen and colleagues (2010) earlier efforts to understand TAP of elite table tennis players (TTP's) with and without ID. TAP was defined as the ability to correctly adapt to specific characteristics of the service (e.g. speed, spin characteristics and direction) and measured by the absolute and relative deviation of the return from a specified target. Limitations of the protocol used in that exploratory study was the basis for the revised testing procedures in the present study. These improvements include more game-like testing simulation, players using their own racket and having human opponent – rather than a robot – deliver the service.

Service and return execution are crucial tactical skills in high-level table tennis competitions because most rallies are decided within the first three strokes (Molodzoff, 2008). Hence, the emphasis in the present study is on the service-return execution more than on tactical strategy during the rally.

The purpose of this study is to compare the TAP of elite TTP's with ID to that of a comparable sample of TTP's without ID. Three main research questions were identified. (1) Is there a difference in TAP between TTPs with and without ID? The hypothesis is that athletes without ID score significantly better. (2) Do ID and non-ID athletes differ in relation to the rate at which TAP improved over the course of the trials? The hypothesis is that athletes without ID improve their score significantly from the moment they are aware of the upcoming service (i.e. between the first and second ball) and remain stable at high levels of TAP between the second and fifth ball, whereas the progression in adaptation is expected to develop more gradually and at lower levels of TAP in athletes with ID. (3) Is there any relationship between intelligence measured by means of IQ and total TAP for the TTP's with ID. Because of the broadness of the IQ measurements, no direct relationship is expected.

Methods

Participants

The data for the study were derived from 41 male and 30 female TTPs with ID. The average age of the players was 27 ± 8 years (male) and 28 ± 8 years (female). The players' IQs ranged between 40 and 75 (mean IQ $= 61 \pm 9$) for the male TTPs and ranged between 37 and 73 (mean IQ $= 57 \pm 10$) for the female TTPs. The average training experience of the ID players was reported by their coaches as 13 ± 5 years. Ninety per cent of the athletes participated in the 2009 INAS (International Federation for Para-athletes with Intellectual Disabilities) World Championships in Czech Republic were tested. All athletes were eligible for competition (i.e. had ID). The participants with ID represented 15 countries from five different continents (Europe, Australia, Africa, South America and Asia). The comparison group, tested at another occasion and location, consisted of 12 male (age $= 24 \pm 12$ years) and five female (age $= 20 \pm 10$ years) TTPs without ID. Self-reported mean training experience was 11 ± 6 years. IQ scores were not available for the comparison group, but all of them graduated from general secondary education and/or were university students. These players were competitive in youth categories or at the regional level in their country. All players took part voluntarily in this study.

Written informed consent was obtained from all participants and/or their legal guardians, prior to the participation in the study. The study was approved by the Medical Ethics Committee of the Catholic University of Leuven.

Procedures

TAP was assessed using a semi-standardised test protocol with a fixed opponent and standardised service delivery. The players were asked to play

12 series of five rallies against an able-bodied TTP (hereafter, referred to as the opponent). There were six service variations delivered in a standardised sequence: no spin to backhand, backspin to forehand, topspin to middle, left sidespin to backhand, backspin-sidespin combination to forehand and topspin–sidespin combination to middle. Each of these variations could be either short or long, so there were 12 service types. Each player received each of the 12 service types five times in a row (five services with no spin followed by five services with backspin, etc.), resulting in a total of 60 services per player. The test battery started with the short service block for half of the players and with the long service block for the other half to control for possible fatigue or learning effects. Each time a player attempted a return and subsequent rally, an expert rated the TAP of the attempt on a scale from 0 to 8 points, with 0 representing minimum TAP and 8 representing maximum TAP. Hence, the resultant TAP score was expressed in points and the maximum per service variation is 40 (8 points per rally $\times 5$ rallies per set).

All male players played against the same male opponent, and all female players against the same female opponent. Both opponents were right-handed and had a comparable level of table tennis expertise. They only differed in playing style: the female opponent being more offensive, and the male opponent more defensive. They were chosen based on their skill level, comparable to the average elite TTP with ID and for their ability to accurately serve balls to precise locations. In the event of a service mistake, the rally was not played, and the service was repeated immediately.

At the start of each set, the player was not told the type of service to be delivered but was instructed that the five services within a set would be identical. The player was directed to 'try to win each rally'. On the opponent's side of the table, a frame was taped to quantify the position of the player's returns afterwards (see Figure 1). The player was not instructed to target any particular zone; however, tactically savvy players know that returns to different types of services are best placed in specific zones. For example, well executed offensive returns are best placed in the grey zones, as depicted in Figure 1, with returns to the middle of the table to be avoided. The correct tactical decision was to aim out of reach for the opponent (shortly behind the net or far forehand/backhand side) or to the body of the opponent. The total test duration was 10–15 minutes, depending on the length of the rallies.

The players were videotaped using a fixed camera that was positioned alongside the middle of the table and set at a height sufficient for capturing the player and the entire table (Figure 1). The images were analysed by table tennis experts using standardised observation protocols.

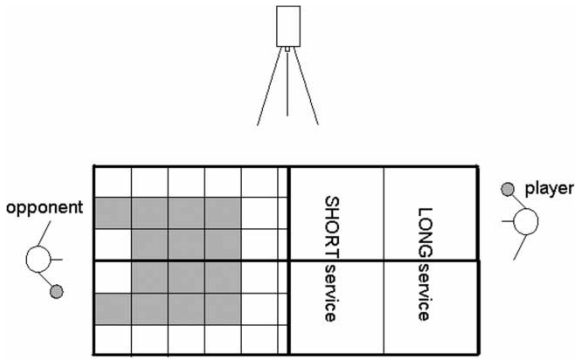

Figure 1. Visual representation of the TAP test battery setup.

Tactical observation protocol

The tactical observational protocol was developed for the purpose of this study because there was no agreement on a standardised or valid instrument used as a gold standard internationally. The protocol was developed in collaboration with five qualified coaches (minimal 10 years of experience) and partially based on existing observation tools known in table tennis (Molodzoff, 2008) and related racket sports practice (O'Donoghue & Ingram, 2001).

Reliability of the protocol was assessed by four independent observers, all experienced TTPs (Carmans & Willems, 2009; Drooghmans & Vandewalle, 2008). In total, more than 50 games of 67 athletes with and without disabilities were videotaped and analysed. Inter- and intra-rater reliability were evaluated using Pearson's correlation coefficients. Inter rater reliability ($r = 0.75$) was calculated by comparing the results of different observers who independently analysed the same games. Intra-rater reliability ($r = 0.90$) was assessed by comparing the results of a single observer who analysed the same games twice within a three-week time interval between observations. Content validity was assessed by in-depth discussions with an expert panel (high-level coaches and players), and the results were compared with analyses of hands-on experts using their own methods of observation.

The first part of the protocol involved determining the players' tactical profile (all-round, offensive or defensive) and racket orientation (forehand, backhand or both sides oriented) by one expert observer. The second part of the protocol was the analysis of each individual rally, for all 60 rallies. The TAP score for each rally was composed by the summed scores of four performance components (return-accuracy, quality of decision, return-effectiveness and variation during the rally), with focus on service-return execution. For each rally, a maximum score of eight points could be obtained.

Table I. Composition of the tactical proficiency score per variable (max score/rally = 8)

Tactical component	Score	Explanation
Return		
Accuracy	0	Mis-hit (in the net or out)
	1	On the table in tactically less appropriate zone (grey zone Figure 1)
	2	On the table in tactically appropriate zone (white zone Figure 1)
Effectiveness	0	No winner
	1	Indirect winner
	2	Direct winner
Quality of decision	0	Incorrect decision for the return
	2	Correct decision for the return
Rally		
Variation/strategy	0	Insufficient strategy/variation in speed and position
	2	Sufficient strategy/variation in speed and position

Table I gives an overview of how the total TAP score was composed. The maximum score per service variation is 40 (8 points $\times$ 5 rallies).

To judge the effectiveness of the return, a return was defined as a direct winner when it was played with sufficient spin or speed or positioned such that the opponent was not able to return the volley. An indirect winner was when the opponent was able to return the ball, but the player ultimately won the point.

Statistical analyses

The SPSS package (version 16.2, SPSS Inc., Chicago IL, USA) was used for the statistical assessment of the hypotheses. The level of significance was set at $p < 0.05$. To quantify the TAP of the players, seven variables were identified. 'Total TAP' was used as the first dependent variable and defined as the average score on TAP over all sets of rallies. It is expressed in points as described in Table I and the maximum is 40 (8 points/rally $\times$ 5 rallies/set). Six spin variables (Table II) were defined as the average TAP in those two rallies, starting with a service of respective spin effect.

To investigate the difference in TAP between players with and without ID, taking possible gender differences into account, a two-way Analysis of Variance (ANOVA) with post hoc Tukey was used with group (ID versus non-ID) and gender as independent variables.

To investigate the adaptation in TAP within all sets of rallies from the first to the fifth identical service, the average TAP score per service was calculated. The variables were expressed in points as described in Table I (max 8 points).

For the analysis of tactical adaptation within each set of services, a two (group: with versus without ID) $\times$ two (gender: male versus female) $\times$ five (service trial) ANOVA was performed with repeated measures on the latter factor.

Finally, a Pearson correlation was calculated between IQ and total TAP of participants with ID.

Results

A 2 $\times$ 2 ANOVA was performed to analyse the differences in TAP scores between TTPs with and without ID for male and female players separately. The overview of average scores on all variables of TAP is given in Table II. The maximum score that was to be obtained per service variable was 40 points (8 points per rally $\times$ 5 rallies per service). Because no significant differences between short and long services for the same service variation were obtained,

Table II. Differences in TAP (max score 40) between male and female players with and without ID

	ID ($X \pm$SD)			No ID ($X \pm$SD)			F	
	Male	Female	Total	Male	Female	Total		
Service variation	$n = 41$	$n = 30$	$n = 70$	$n = 12$	$n = 5$	$n = 17$	Group	Gender
Spin								
No	17.9 $\pm$ 4.7	16.6 $\pm$ 4.9	17.4 $\pm$ 4.8	27.1 $\pm$ 4.2	22.8 $\pm$ 5.5	25.8 $\pm$ 4.9	30.6**	4.1*
Back	15.2 $\pm$ 4.9	15.4 $\pm$ 3.7	15.3 $\pm$ 4.4	24.5 $\pm$ 4.1	24.3 $\pm$ 3.8	24.4 $\pm$ 3.9	51.4**	0
Top	16.1 $\pm$ 4.1	13.6 $\pm$ 4.9	15.0 $\pm$ 4.6	26.0 $\pm$ 5.2	22.0 $\pm$ 4.3	24.9 $\pm$ 5.2	47.4**	6.0*
Side	19.0 $\pm$ 4.9	17.9 $\pm$ 4.7	18.5 $\pm$ 4.8	27.2 $\pm$ 4.3	24.2 $\pm$ 2.9	26.3 $\pm$ 4.1	27.8**	2,3
Back/side	17.6 $\pm$ 5.4	16.3 $\pm$ 4.3	17.1 $\pm$ 5.0	25.9 $\pm$ 3.1	21.8 $\pm$ 6.5	24.7 $\pm$ 4.6	23.5**	3,7
Top/side	16.8 $\pm$ 5.0	13.1 $\pm$ 4.4	15.2 $\pm$ 5.0	26.2 $\pm$ 3.6	23.7 $\pm$ 2.8	25.4 $\pm$ 3.5	57.0**	5.4*
Total	17.1 $\pm$ 3.2	15.5 $\pm$ 2.7	16.4 $\pm$ 3.1	26.1 $\pm$ 2.1	23.1 $\pm$ 2.7	25.3 $\pm$ 2.6	95.7**	7.5*

*$p \leq 0.05$, **$p < 0.01$.

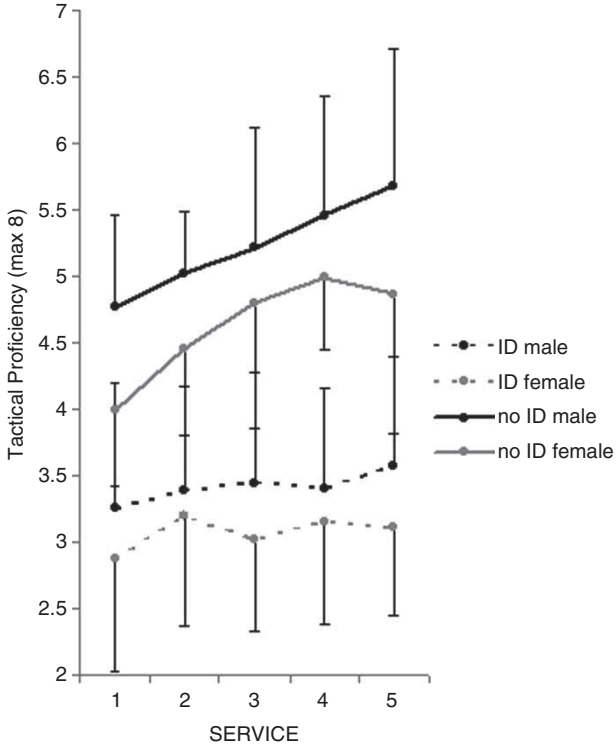

Figure 2. Progress of total TAP per service within all sets of five rallies, starting with identical service.

the average score on long and short services was reported per service variation.

The analysis yielded significant group effects between players with and without ID for all variables ($p < 0.01$), whereby players without ID scored better than players with ID.

Figure 2 presents the mean total TAP score over the service trials within all sets of five rallies for male and female TTPs with and without ID separately. TAP was scored out of eight points per rally as indicated in Table I. The analysis yielded a significant main effect for group, F (3, 86) = 44.4, $p < 0.001$. Post hoc analyses (Tukey) indicated that the total TAP score was lower for TTPs without ID than for players with ID. The analysis also yielded a significant main effect for service trial, F (4, 86) = 4.7, $p < 0.05$, indicating that the TAP scores improved from service one to service five. The data revealed an improvement in TAP between service one to service five of 4.0% (ID male) and 3.0% (ID female) compared to 11.4% (no ID male) and 10.9% (no ID female). However, no significant effect for service trial × group was found, indicating that this observed difference in proficiency is not significant and all four groups improved their TAP score over the five service trials substantively.

There was no significant correlation (Pearson r = 0.08, $p > 0.05$) between the total TAP and IQ scores of the TTPs with ID.

Discussion

This study addressed TAP of TTPs with and without ID. The male and female subsamples were analysed separately. The observed differences between athletes with and without ID were in line with our hypotheses. It is known that success in sport is not only dependent on physical and motor capabilities but also on perceptual and cognitive skills (Williams, 2002), therefore, TAP was believed to be lower in athletes with ID compared to athletes without ID. As expected, all participants were able to improve their scores from the first to the fifth rally within a set, making use of the information that five subsequent rallies would start with an identical service. Athletes without ID improved their score more from the first to the fifth service more (11%) than the athletes without ID (4%), but this difference was not significantly different. No direct relation between IQ and TAP was observed.

Research about TAP in athletes with ID is scarce. As such related bodies of literature concerning talent identification and expert performance in elite sport (Abernethy, 1991; Allard, 1993; Baker, Cote, & Abernethy, 2003; Berry, Abernethy, & Côté, 2008; Raab et al., 2005; Starkes & Ericsson, 2003; among others) and within the research area of motor development in young children, giving considerable attention to how the development of TAP occurs (Haywood & Getchell, 2009; Thomas et al., 2001).

To the authors' knowledge, the only other study investigating measures of TAP of high-level athletes with ID is the afore-mentioned study by Van Biesen et al. (2010). The 39 male elite TTPs with ID in that study were significantly less proficient than their counterparts without ID in returning services with various spin effects to a fixed target. Based on the results of the study by Van Biesen et al. (2010), where athletes without ID reduced their errors significantly between the first and the second ball, a plateau in TAP scores was expected in athletes without ID between the second and last ball. In the present study, however, this plateau was not observed in athletes without ID. A likely explanation for this discrepancy is the fact that the balls in the present study were delivered by an opponent instead of a robot. As a consequence, the movement patterns (arm swing and racket motion) of the opponent were now part of the essential visual information available for the anticipation of decision from the first ball on, which might explain the better performance from the first ball on.

A few other studies addressed abilities related to TAP in persons with intellectual disabilities, but this occurred under laboratory conditions out of sport settings and in non-sports populations (Carmeli, Bar-Yossef, Ariav, Levy, & Liebermann, 2008;

Newell, Wade, & Kelly, 1979). According to Carmeli et al. (2008), persons with ID have difficulties with the integration of perceptual information into motor action. In their experiments, they showed in a sample of adults with mild ID that hand–eye coordination was poor, particularly when a quick response to perceptual stimuli was required. They also found that people with mild ID lacked the fundamental ability to rotate mentally the location of an object in space and that they failed to integrate an internal visual image into the appropriate motor commands. These findings could contribute to the explanation of our results because table tennis is a sport played in a confined space that necessitates well-developed pattern recognition and spatial awareness skills to know where the opponent and the ball are at all times (Baker et al., 2003). Another ability related to successful performance in open skills is the ability to anticipate temporally. Open skills are skills in which the environmental contingencies can vary from situation to situation, such as rapid ball games (Starkes & Allard, 1993). The extent to which persons with ID can temporally anticipate and pre-programme a motor response that requires a reasonable degree of speed and precision was investigated by Newell et al. (1979) in two laboratory experiments. Their key finding was that the ability of persons with ID to anticipate interacts with the complexity of the response. When the response details were minimal, as in a simple releasing-response, temporal anticipation occurred. When the response demanded some precision relative to spatial and temporal criteria, no beneficial anticipation occurred. In table tennis, the performance of every single stroke requires spatial and temporal anticipation. The player needs to select an appropriate response for the return, based on the actions of the opponent and the characteristics of the ball trajectory. In our experiment, the complexity of the task decreased within every set of five rallies because the player was aware of the service characteristics. This could contribute to the explanation of the results that the players with ID were able to improve their scores progressively. We hypothesised that performance should be better in conditions in which players are aware of the upcoming service as opposed to situations in which players do not know what service to expect. Literally that would mean the players would improve significantly between the first and second service and then reach a plateau. Despite all this, the realistic condition in a table tennis game is that you never know what service to expect, so the crucial skill is to judge and react to every single service appropriately. The results indicated that players without ID were able to do this as they improved their score from 4.3 to 5.2 points between the first and fifth return, whereas athletes with ID still scored below average on the last service (improvement from 3.0 to 3.3 points).

Two other cognitive measures recently proposed as predictors of talent include intelligence and creative thinking. It has been suggested by Williams and Reilly (2000) that elite performers possess a 'game intelligence' that allows them to read the game and successfully interpret the features of their opponents play to adapt their own strategy and decision-making. It has not been clearly demonstrated, but this 'game intelligence' might be related to the overall intelligence of a player, which would entail a major disadvantage for players with ID.

Limitations

We are aware of some critical issues within our design that need to be controlled for in further experiments. The appropriateness of actions taken by the player during the standardised test represents the players' TAP. However, the assessment of these actions is not an exact measure of TAP. The appropriateness of these actions may be influenced both by the technical proficiency (ability to execute the desired skill) and the abilities of the opponent. The choice was deliberately made to pit against an opponent instead of a machine to conduct the test in circumstances as close to reality as possible. Within our approach, it is impossible to control slight day-to-day or game-to-game variations in performance of the opponent. Furthermore, we can only speculate about the exact impact of the impairment on TAP because no detailed information about the impairment is investigated (other than IQ scores). Finally, the age range within the control group was large and two youth players were aged 12 and might be considered as children; whereas the youngest ID player was 17 years old. Future research will address these limitations. It might also be worthy to look into possible gender differences more detailed. For this investigation, the authors preferred to treat the male and female subsamples separately.

Implications

This study is embedded in the overall IPC-INAS classification research project, to investigate the impact of impairment on sport-specific performance. Assessing the sport proficiency of high-performance athletes with ID is important within the development of new classification systems in their quest for future participation in the Paralympic Movement. One of the conditions stipulated by the International Paralympic Committee (IPC) in its position statement (Tweedy & Vanlandewijck, 2009) concerning the development of sport-specific evidence-based classification systems for paralympic athletes is that there should be scientific evidence that the impairment impacts on the specific sport. As shown again in this study, there is no

direct linear relationship between IQ and sport performance; probably because of the broadness of the concept and different ways of measuring IQ. Findings of this study will serve as a basis for future investigations, addressing the impact of intellectual impairment on sport performance. IQ will be narrowed down only to those components of intelligence that may have an impact on performance in sport.

Another suggestion will be the amelioration and validation of the protocol for assessing TAP by correlating the TAP scores with rally outcome and win/loss ratio in on-court competition situations.

Conclusion

In conclusion, athletes with ID are able to slightly improve their TAP over five rallies, starting with an identical service, but their performance is at significantly lower levels in comparison to a sample of athletes without ID. The results of the present study indicate that there might be evidence for a direct impact of the impairment on sport-specific performance, but further research is needed.

Acknowledgements

The authors thank INAS (International Federation for Para-athletes with Intellectual Disabilities) and International Paralympic Committee (IPC).

References

AAIDD. (2010). *Intellectual disability, definition, classification and systems of support* (11th ed.). Washington, DC: Author.

Abernethy, B. (1991). Visual search strategies and decision-making in sport. *International Journal of Sport Psychology*, *22*, 189–210.

Allard, F. (1993). Cognition, expertise, and motor performance. In J. L. Starkes & F. Allard (Eds.), *Cognitive issues in motor expertise* (pp. 17–34). Amsterdam: Elsevier.

Anderson, M., & Miller, K. L. (2002). Modularity, mental retardation and speed of processing. *Developmental Science*, *1*(2), 239–245. doi:10.1111/1467-7687.00037

Baker, J., Cote, J., & Abernethy, B. (2003). Sport-specific practice and the development of expert decision-making in team ball sports. *Journal of Applied Sport Psychology*, *15*(1), 1225. doi:10.1080/10413200305400

Berry, J., Abernethy, B., & Côté, J. (2008). The contribution of structured activity and deliberate play to the development of expert perceptual and decision-making skill. *Journal of Sport & Exercise Psychology*, *30*, 685–708. Retrieved from http://www.thefa.com/GetIntoFootball/FALearning/FALearningPages/~/media/Files/PDF/Get%20into%20Football/FA_Learning_YouthModule2/The%20Contribution%20of%20Structured%20Activity.ashx/The%20Contribution%20of%20Structured%20Activity.pdf

Carmans, D., & Willems, M. (2009). *Optimalisatie van een observatieprotocol voor het meten van de tactische vaardigheid in tafeltennis bij spelers met een verstandelijke handicap* [The optimization of an observational protocol to measure tactical proficiency in table tennis for athletes with intellectual disabilities] (Unpublished master's thesis). Catholic University, Leuven, Belgium.

Carmeli, E., Bar-Yossef, T., Ariav, C., Levy, R., & Liebermann, D. G. (2008). Perceptual motor coordination in persons with mild intellectual disability. *Disability and Rehabilitation*, *30*(5), 323–329. doi:10.1080/09638280701265398.

Coackly, J. (1993). Sport and socialization. *Exercise and Sport Sciences Reviews*, *21*, 169–200.

Dexter, T. (1999). Relationships between sport knowledge, sport performance and academic ability: Empirical evidence from GCSE physical education. *Journal of Sports Sciences*, *17*(4), 283–295. doi:10.1080/026404199366000.

Di Blasi, F. D., Elia, F., Buono, S., Ramakers, G. J. A., & Di Nuovo, S. F. (2007). Relationships between visual-motor and cognitive abilities in intellectual disabilities. *Perceptual and Motor Skills*, *104*(3), 763–772. doi:10.2466/pms.104.3.763-772.

Drooghmans, N., & Vandewalle, M. (2008). *Evaluatie van de tafeltennisprestatie van elite spelers met een verstandelijke handicap: betrouwbaarheid van een observatieprotocol* [Evaluation of the table tennis proficiency of elite athletes with intellectual disabilities: Reliability of the observational protocol] (Unpublished master's thesis). Catholic University, Leuven, Belgium.

French, K. E., & Thomas, J. R. (1987). The relation of knowledge development to children's basketball performance. *Journal of Sport Psychology*, *9*, 15–32.

Haywood, K. M., & Getchell, N. (2009). *Life span motor development* (5th ed., 391 p). Champaign, IL: Human Kinetics Publishers.

McPherson, S. L., & Thomas, J. R. (1989). Relation of knowledge and performance in boys' tennis: Age and expertise. *Journal of Expert Child Psychology*, *48*: 190–211. doi:10.1016/0022-0965(89)90002-7

Molodzoff, P. (2008). *Table tennis advanced coaching manual* (353 p). Lausanne: ITTF.

Newell, K. M., Wade, M. G., & Kelly, T. M. (1979). Temporal anticipation of response initiation by mentally retarded persons. *American Journal of Mental Deficiency*, *84*(3), 289–295.

O'Donoghue P., & Ingram, B. (2001). A notational analysis of elite tennis strategy. *Journal of Sports Sciences*, *19*(2): 107–115. doi:10.1080/026404101300036299.

Raab, M., Masters, R. S. W., & Maxwell, J. P. (2005). Improving the 'how' and 'what' decisions of elite table tennis players. *Human Movement Science*, *24*(3), 326–344. doi:10.1016/j.humov.2005.06.004.

Starkes, J. L. (1987). Skill in field hockey: The nature of the cognitive advantage. *Journal of Sports Psychology*, *31*, 431–451.

Starkes, J. L., & Allard, F. (Eds.). (1993). *Cognitive issues in motor expertise* (365 p). Amsterdam: North-Holland.

Starkes, J., & Ericsson, K. A. (2003). *Expert performance in sports. Advances in research on sport expertise*. Champaign, IL: Human Kinetics.

Thomas, K. T., Gallagher, J. D., & Thomas, J. R. (2001). Motor development and skill acquisition during childhood and adolescence. In R. N. Singer & H. A. Hausenblas (Eds.), *Handbook of sport psychology* (pp. 20–52). New York, NY: Wiley.

Tweedy, S. M., & Vanlandewijck, Y. (2009). International paralympic committee position stand – Background and scientific rationale for classification in paralympic sport. *British Journal of Sports Medicine*, *43*(13), 1067–1072. doi:10.1136/bjsm.2009.061804.

Van Biesen, D., Verellen, J., Mactavish, J., Meyer, C., Van de Vliet, P., & Vanlandewijck, Y. (2010). The ability of elite table tennis players with intellectual disabilities to adapt their service/return. *Adapted Physical Activity Quarterly*, *27*(3), 242–257.

Williams, A. M. (2002). Perceptual and cognitive expertise in sport. *The Psychologist*, *15*(8), 416–418.

Williams, A. M., & Reilly, T. (2000). Talent identification and development in soccer. *Journal of Sports Sciences*, *18*(9), 657–667. doi:10.1080/02640410050120041.