Determinants for table tennis performance in Elite Scottish Youth players using a multidimensional approach

Determinants for Table Tennis Performance in Elite Scottish Youth Players Using a Multidimensional Approach: A Pilot Study

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Date of initial submission: October 06, 2017.

Date of submission revised version: April 16, 2018.

Date of submission second revised version: May 23, 2018.

Word count (excl. abstract & references):	3982
Abstract word count:	196
Number of tables:	2
Number of supplementary material:	1

Acknowledgements & Funding

We acknowledge the children, parents and coaches for their cooperation in data-collection. Special thanks go to the club members who provided the equipment and facilities and supported the research. No financial support was provided for this study.

Disclosure of interest

The authors report no conflicts of interest.

Abstract

The purpose of the study is to explore whether a multidimensional profiling approach can be useful in predicting a table tennis player's actual and future (one year later) performance. Data on anthropometrics, age from peak height velocity, motor-skills, psychological skills and training histories were gathered among Scottish elite youth male table tennis players (n=14). Significant correlations emerged between: (a) actual performance rating and age from peak height velocity (r = .71), sprint test (r = -.69), number of years of practice (r = .84), positive refocusing (r = -.58), and self-regulation in learning – self-monitoring (r = -.60), and evaluation (r = .57); (b) performance rating one year later and positive refocusing (r = -.58), self-monitoring (r = -.50) and number of years of practice (r = .80). Results also showed significant correlations between progression scores (2017 rating score minus 2016 rating score) and age from peak height velocity (r = -0.77), sprint test (r = .63), number of years of practice (r = -.52), self-monitoring (r = .69), and evaluation (r = -.58). These results provided preliminary evidence for the usefulness of a multidimensional profiling approach for predicting performance and progression in youth table tennis players.

Keywords: aptitude; racquet sports; talent development; predictive value of test

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The concept of talent has a long history of dividing opinion. In 1865, Sir Francis Galton first conducted research into the possibility that excellence in different fields shares commonalities (Galton, 1865). He concluded that offspring inherit natural ability from their parents, which allows them to display expert/elite performance in a certain field. In the years following Galton's research, scholars have debated the importance of nature and nurture for the attainment of expert performance. Today, several researchers have moved on from this debate and instead focus their attention on explaining the complex relationships between nature, nurture and talent (Vaeyens, Lenoir, Williams, & Philippaerts, 2009). A current leading theory is that talent is a multidimensional, multiplicative and dynamic process (Simonton, 2001). Crucially, Simonton argues that the concept of talent has been over simplified and instead offers a complex model, which acknowledges the multifaceted nature of talent. Today Simonton's view is widely accepted by scholars (Reilly, Williams, Nevill, & Franks, 2000; Faber, Bustin, Oosterveld, Elferink-Gemser, & Nijhuis-Van Der Sanden, 2015a), yet there are still many sport associations that rely on overly simplistic and unidimensional talent identification models (Abbott, Button, Pepping, & Collins, 2005).

In 1993, Ericsson, Krampe and Tesch-Römer published a seminar paper detailing their theory of deliberate practice in which, they dismiss a correlation between natural ability and expert performance. Deliberate practice is described by Ericsson et al. (1993) as relevant and effortful practice, undertaken with the specific goal of improving performance. Ericsson et al. found that differences in levels of expertise could be attributed to factors other than talent, most notably how many hours of deliberate practice each individual had undertaken. Despite Ericsson et al.'s paper gaining much support, providing the inspiration for the commonly known 10,000 hour rule (Gladwell, 2008), their research also received much criticism. Ackerman (2013) claims that scholars who support the deliberate practice approach such as Ericsson et al. (1993), fail to acknowledge cases where different performers have undertaken extensive practice, but have not displayed comparatively high levels of performance. Ericsson, Roring and Nandagopal (2007) state that such incidents can be attributed to factors underpinning the development of players, such as quality of coaching, access to facilities, and financial support. Ackerman (2013) acknowledges the contribution of developmental factors. Nevertheless, he states that some differences in talent must be due to natural ability. Thus, contrary to Ericsson et al. (1993), he states that giftedness does exist and that it must contribute to the attainment of expert performance. Currently, the overall consensus on expert performance in sport is that some element of both nature and nurture play a role in determining success (Davids & Baker, 2007; Tucker & Collins, 2012). This study will employ a multidimensional approach to talent identification and development in table tennis, which acknowledges the potential importance of both nature and nurture.

Expert performance in the modern era of table tennis places a multitude of demands on an individual. Table tennis is a complex motor task which forces a player to plan and coordinate their movements in a very small time frame (Faber, Nijhuis-Van Der Sanden, Elferink-Gemser, & Oosterveld, 2015b). Expert performance requires postural control, fast footwork, the ability to anticipate, fast reaction time, and refined technical ability (Ak & Kocak, 2010; Akpinar, Devrilmez, & Kirazci, 2012; Seve, Saury, Thereau, & Durand, 2002). An individual must be able to adjust their movements to the infinite variations of speed, direction, height and spin that can be placed on the ball (Limoochi, 2006; Rodrigues, Vickers, & Williams, 2002). Short and intense points mean players predominantly use the anaerobic energy system. At an elite level, aerobic capacity is also paramount to facilitate recovery between matches; international events usually last five to seven days with matches on consecutive days (Kondric, Zagatto, & Sekulic, 2013). Moreover, in order to undergo the volume and intensity of training necessary, expert performers must possess various psychological qualities related to motivation, mental toughness, self-regulation, and emotional regulation (Jonker, Elferink-Gemser, & Visscher, 2010; Chu, Chen, Chen, Huang, & Hung, 2012; Lopez & Santelices, 2012). These psychological variables were selected, because they are likely to help junior players to develop into elite players at senior level (Faber, 2016; Gucciardi, Hanton, Gordon, Mallett, & Temby, 2015). Junior table tennis players are confronted with a series of demands during their career and their competitive season such as a demanding training schedule or intense competitive environment (Martinent, Decret, Guillet-Descas, & Isoard-Gautheur, 2014). Therefore, maintaining a high level of motivation and engagement using emotional regulation strategies to manage stressful events and being able to perform functionally in highly demanding environments (mental toughness) are considered by several researchers and sport psychologists as important qualities that junior players need to develop (Chu et al., 2011; Gucciardi et al., 2015; Lonsdale, Hodge, & Rose, 2008; Martinent & Decret, 2015; Martinent, Ledos, Ferrand, Campo, & Nicolas, 2015). Previous studies also provided evidence that self-regulation of learning (i.e., self-directed processes that help individuals learn more effectively) is a crucial factor in talent development (Jonker et al., 2010; Toering, Elferink-Gemser, Jonker, van Heuvelen, & Visscher, 2012). Due to the complex nature of both table tennis and talent, the task of identifying talent in table tennis players is a significant challenge.

This study employs a multidimensional profiling model for table tennis proposed by Faber et al. (2015a). At present, no other known study has researched critical determinants of performance of elite table tennis players using a multidimensional model. Such a model would allow national associations and coaches to assess a diverse range of variables, all of which are hypothesized to contribute to (future) expert performance. At present, a wide range of national table tennis associations do not use such a talent identification or development model. Rather, most of the national table tennis associations select youth players for training groups and competitions based mainly on the current performance level. As a minority sport in a relatively small nation, Table Tennis Scotland has the challenge of maximizing the potential of their players with limited resources. A multidimensional profiling model as proposed by Faber et al. (2015a) could facilitate an improvement in talent development with reasonably low expense. It would allow coaches to identify strengths and weaknesses in each individual and recognize how certain factors may be limiting talent development (Abbott et al., 2005).

The purpose of the study is to explore whether a multidimensional profiling approach (Faber et al., 2015a) including training history, anthropometric, the age from peak height velocity (i.e. the time pre or post the onset of peak growth velocity which is a commonly used indicator of maturity in adolescents, Mirwald, Baxter-Jones, Bailey & Beunen, 2002), motor-skill (eye-hand coordination and sprint test) and psychological (motivation, engagement, mental toughness, emotional regulation and self-regulation in learning) factors can be useful in predicting table tennis player's performance. In particular, the research explored: (a) the relationships between aforementioned variables grounded within the multidimensional profiling model and the actual and future (one year later) performance of table tennis players; and (b) the relationships between aforementioned variables from the multidimensional profiling model and the one-year progression of table tennis players. Given the exploratory nature of the study, we did not test specific hypotheses.

Methods

Ethics statement

This study and informed consent procedures were approved by the Moray House School of Education (University of Edinburgh) ethics committee. A basic certificate was obtained from Disclosure Scotland (an executive agency of the Scottish Government) to ensure eligibility to work with children. Written informed consent was obtained for all participating players and their parents.

Participants

A purposive sample of 14 male Scottish junior table tennis players (*M* age = 15.3 years, *SD* = 1.2) were recruited through written invitation. To be included in the study participants were required to be male, eligible to compete in the junior (under 18) category, and ranked between one and twenty-five in the junior national ranking list. The ranking system 'Ratings Central' (Ratings Central,

2016) was used to provide the player ranking list. It records all of a player's results in national competitions, adding points for wins and subtracting points for losses, resulting in a rating.

Design

This study used an observational prospective design. Anthropometrics, motor-skills, psychological skills, training history information and performance scores (performance rating) were gathered over a period of two months. The performance rating was recorded again one year later.

Data collection

A test battery was used to measure anthropometry, maturity, motor and psychological skills and training history. Each player individually first completed questionnaires concerning their training history and the psychological skills. Consecutively, anthropological and motor-skill data were gathered during a test session as part of their table tennis training. All participants were tested under similar conditions in a training hall. The tester was familiarized with the test protocols and trained by an expert table tennis trainer.

Anthropometry and age from peak height velocity

Anthropometric measures included weight, standing height and sitting height. The age from peak height velocity (APHV) value for each individual was calculated using Mirwald et al.'s (2002) equation using standing height, sitting height and chronological age. APHV is the most commonly used indicator of maturity in longitudinal studies of adolescence (Mirwald et al., 2002). It provides an accurate benchmark of the maximum growth during adolescence and provides a common landmark to reflect the occurrence of other body dimension velocities within and between individuals using the known differential timings of growth of height, sitting height and leg length.

Motor-skills

The eye-hand coordination test and the sprint test were selected from the Dutch motor skills assessment and have demonstrated adequate validity and reliability (Faber, Oosterveld, & Nijhuis-Van der Sanden, 2014). The eye-hand coordination test assesses the player's ability to make accurate and coordinated hand and arm movements at a high rate. Players are required to throw a table tennis ball against a table tennis table, which has been set up standing vertically upright. They must throw and catch the ball with alternate hands from a distance of one meter as many times as possible in 30 seconds. All players have two attempts and the highest score of correctly caught balls is recorded.

The sprint test assesses a player's ability to accelerate and make direction changing turns quickly in combination with a manual task (Faber et al., 2014). Five trays with a table tennis ball in each are placed at specific positions in a pyramid shape circuit (Faber et al., 2014; 2015a). The player is instructed to get the balls from each trey one by one to the starting position and also bring them back as quickly as possible. Players have two attempts with sufficient rest in between and the fastest time is recorded in seconds (for a full description see Faber, Elferink-Gemser, Faber, Oosterveld, & Nijhuis-Van der Sanden, 2016).

Psychological skills

A battery of theoretically-relevant questionnaires was used to assess various psychological skills involved in talent development (sport motivation, engagement, emotional regulation, mental toughness, and self-regulation in learning). The Behavioral Regulations in Sport Questionnaire (BRSQ; Lonsdale et al., 2008) was used to assess six distinct players' motives for table-tennis using four-item subscales: intrinsic motivation, integrated regulation, identified regulation, introjected regulation, external regulation, and amotivation. Participants responded to each of the items using a Likert-type scale ranging from (1) not at all true, to (7) very true. Engagement was assessed with an adaptation to the sporting context of the short form of the Utrecht Work Engagement Scale (UWES-9; Schaufeli, Bakker, & Salanova, 2006). The UWES-9 is comprised of three three-item subscales measuring vigor, dedication, and absorption through a Likert-type scale ranging from (0) never, to (6) always. The short version of the Cognitive Emotion Regulation Questionnaire (short CERQ; 18 items; Garnefski & Kraaij, 2006) was used to measure adaptive (positive refocusing, positive reappraisal, putting into perspective, refocusing on planning, acceptance) and maladaptive emotional regulation strategies (rumination, self-blame, blaming other, catastrophizing) that characterise the player's style of responding to stressful events through a Likert-type scale ranging from (1) almost never, to (5) almost always. The Mental Toughness Index (MTI; 8 items; Gucciardi et al., 2015) was used to assess mental toughness from a unidimensional perspective through a Likert-type scale ranging from (1) false, 100% of the time, to (7) true, 100% of the time. Finally, the Self-Regulation of Learning Self-Report Scale (SRL-SRS; Toering et al., 2012) was used to assess the six dimensions of the self-regulation of learning concept: reflection (5 items), evaluation (8 items), planning (8 items), self-monitoring (6 items), effort (9 items), and self-efficacy (10 items). The reflection and evaluation items were completed using a Likert-type scale ranging from (1) strongly disagree/never, to (5) strongly agree/always whereas the planning, self-monitoring, effort and self-efficacy items were answered using a 4 Likert-type scale ranging from (1) almost never to (5) almost always (Toering et al., 2012). Previous research lent credit to the validity and reliability of BRSQ, UWES-9, short CERQ, MTI, and SRL-SRS scores (Garnefski & Kraaij, 2006; Gucciardi et al., 2015; Lonsdale et al., 2008; Schaufeli et al., 2006; Toering et al., 2012).

Training history

Data for training history was gathered using a questionnaire requesting participants to outline how many years and the total training volume (hours) they had been actively practicing table tennis with a coach.

Statistical Analysis

IBM SPSS Statistics 22 for Windows (IBM Corp., Armonk, NY, USA) was used for the statistical analyses. Due to the violation of normality for some variables, the Spearman's rank-order correlation was used to examine the relationships between the player's performance ratings (at the time of first data gathering and one year later) and the motor-skill (e.g., sprint test, eye-hand test) and psychological (e.g. engagement, emotional regulation strategies) abilities as well as training history and anthropometric variables. Effect sizes can be defined as small ($0.3 < r < 0.5$), moderate ($0.5 < r < 0.7$), or large ($0.7 < r$) (Hinkle, Wiersma, & Jurs, 2003).

Results

Table 1 presents the descriptive of all the study variables: anthropometry, age from peak height velocity, motor skills, psychological skills, training history and table tennis performance. Only one outlying data point was identified; one player scored more than -3 standard deviations away from the mean of the variable integrated regulation.

****INSERT TABLE 1 NEAR HERE****

Results of Spearman's rank-order correlations are presented in Table 2. Results showed significant ($P<.05$) correlations between actual performance rating and APHV (r = .71), sprint test (r = -.69), number of years of practice (r = .84), emotional regulation (i.e., positive refocusing; r = -.58), and two dimensions of self-regulation in learning – self-monitoring (r = -.60), and evaluation (r = .57). Otherwise, performance rating one year later was significantly correlated with positive refocusing (r = -.58) and number of years of practice (r = .80) and marginally ($P \leq .09$) correlated with self-monitoring (r = -.50). Finally, results showed significant correlations between progression scores (2017 rating minus 2016 rating) and APHV (r = -0.77), sprint test (r = .63), self-monitoring (r = .69), and evaluation (r = -.58), whereas progression scores were marginally correlated with number of years of practice (r = -.52).

Moreover, a detailed correlation matrix of all included variables is added as supplemental online material. Albeit non-significant (probably because of the small sample size), some correlations were higher than .30 or lower than -.30: (a) the correlations between actual performance rating and mental toughness (r = .32), integrated regulation (r = -.32), identified regulation (r = -.38), introjected regulation (r = -.34), refocus on planning (r = .47), planning (r = .52), and effort (r = .43); (b) the correlations between performance rating one year later and APHV (r = .45), sprint test (r = -.44), introjected regulation (r = -.33), acceptance (r = -.32), refocusing on planning (r = .49), blaming others (r = -.35), evaluation (r = .34), planning (r = .52), and effort (r = .50); and (c) the correlations between progression scores and dedication (r = .37), intrinsic motivation (r = .43), integrated regulation (r = .37), identified regulation (r = .33), amotivation, (r = -.43), planning (r = -.32) and training history (r = -.52).

****INSERT TABLE 2 NEAR HERE****

Discussion

A group of Scottish elite junior table tennis players were profiled using a multidimensional model to test for distinguishing factors of performance and development. The primary determinants of development in this sample were APHV, sprint time, self-regulation and number of years of practice. These results provide preliminary evidence for a multidimensional profiling approach as training history, anthropometrics, motor and psychological skills were significantly related to both performance and progression scores. The players were likely to improve their performance more over the course of the year if they were less physically mature, had a slower sprint time, and had practiced less at the initial time of testing. It is theorised that the greater performance increase was primarily due to the physical maturation those players would have experienced during the one year period. The strongest correlation was observed between performance scores and training history. The players who had practiced for longer and for more hours were likely to be at a higher performance level at both time points. This is thought to be due to the extra practice time amassed by the higher ranked players, allowing them to develop and refine their sport specific abilities to a higher level. Consequently, mapping these performance determining characteristics might be beneficial for talent development purposes.

The significant correlations between both APHV and sprint time with the progression scores reveals the important role that physical maturation, for which APHV can be used as proxy, can play in the performance development of young table tennis players. The results show that the slower and less physically mature (i.e., lowest APHV) players were able to progress more during the year than their faster and more physically mature counterparts, suggesting that they were able to do so due to their own natural physical development. These results suggest that physical attributes may be one of the primary determinants of performance development in elite youth table tennis players. These results are in line with other studies on physical maturation that have shown that even a difference of a few months in age may have a significant effect on athletic development

(Cobley, Baker, Wattie, & McKenna, 2009). Furthermore, it aligns to a previous study that shows the predictive value of the sprint test for performance in youth table tennis players (Faber et al., 2016).

The significant correlations found for psychological skills suggest that self-monitoring and evaluation (two dimensions of self-regulation) had an influence on performance and progression. However, the results were somewhat contradictory since evaluation was positively and self-monitoring negatively correlated with performance rating (Toering et al., 2009). The significant negative correlations of positive refocusing for both performance ratings suggest this may be a skill that is required be lower rated players, perhaps since they are likely to experience more defeats than the higher rated players. Although several psychological skills (e.g., sport motivation, engagement, mental toughness) were non-significantly related to performance and progression scores, it is noteworthy that some correlations showed a size of at least .30 (or -.30). Confirming the postulates of the self-determination theory, progression scores were (non-significantly) positively correlated with self-determined forms of motivation (i.e., intrinsic motivation, integrated and identified regulations) and negatively correlated with amotivation (Martinent et al., 2015). Evaluation, planning and/or effort (i.e., three dimensions from the self-regulation concept) were (non-significantly) positively correlated with actual performance rating, performance rating one year later and progression scores. Otherwise, mental toughness was (non-significantly) positively correlated with actual performance rating whereas dedication (one dimension from the engagement concept) was (non-significantly) positively correlated with progression score. As a whole, it is theorised that psychological skills were not strong determinants of performance or development in this study due to the nature of the sample. Psychological skills might mainly be determinants of performance amongst a group of elite players who have similar physical and technical competencies. Due to the variation in age and training history of the participants, physical maturity and sport specific technical ability were more influential. It is also possible that the timing of data collection (i.e. one year between data gathering of psychological variables and the performance ratings) could explain the weak number of significant variables observed between psychological variables and performance/progression scores. Hence, if psychological variables could not necessarily provide a direct advantage or disadvantage in short term performance development (e.g., one year later), psychological variables could be more strongly related to future performance levels of these players in the long term (e.g., five years later) (Martinent, Cece, Elferink-Gemser, Faber, & Decret, in press).

The results of the analysis of number of years of practice highlight the influence of training history on performance and development. These results are consistent with previous research conducted on other sports (Davids & Baker, 2007; Phillips, Davids, Renshaw, & Portus, 2010). It is suggested that the extra practice time amassed by the higher rated players has allowed them to develop and refine their sport specific abilities to a higher level than the lower rated elite players (Ericsson et al., 1993). The central nervous systems of the higher rated players have received a higher level of conditioning through practice, allowing their muscles to perform within the unique demands of table tennis more effectively than the lower rated players (Knudsen, 2004).

This research study would have benefited from another round of profiling using the multidimensional model alongside the recording of the performance ratings one year following the initial profiling. This would have given a clearer insight into which variables may have had an influence on the progression scores and performance ratings one year later. Future research of a multidimensional profiling model should aim to develop methods to acquire relevant information regarding each individual's history of sport and activity, as studies have shown that ability is transferrable between different sports (Davids & Baker, 2007). Although table tennis is generally regarded as a sport requiring early start for expert performance (Faber et al., 2015a), experience in similar activities at a young age may mean talent development is not hindered by an absence of early specialisation. Future research should also aim to include considerations for other developmental factors, which are known to be important for the development of young athletes, such as parental support and access to quality coaching (Côte, 1999). This data could allow coaches and sports scientists to develop a more detailed profile of every individual. To build upon the research of this study, a similar study on elite senior table tennis players in Scotland would also be beneficial. Profiling adults would reduce the potential effect of physical maturity and hours of practice on assessment results, allowing more emphasis to be placed on the assessments of motor-skills and psychological factors. Also, as Scotland is a relatively small table tennis nation with a low level of participation, these findings may not be strictly relevant to larger table tennis nations that have thousands of players at each age category. In addition, it's possible that the lack of significant correlations between certain factors is due to the size of the studies' sample. As such, the findings of this study should be applied to other nations and groups of players with careful consideration.

In conclusion, assessing maturity, motor skills (sprint), psychological skills (self-regulation in learning) and table tennis experience are likely to support talent development programs for elite youth table tennis players, since these determinants showed significant associations with table tennis performance and progression. These findings support the view that the focus of talent models should be directed towards development, rather than selection (Wolstencroft, 2002). Longitudinal studies that use a multi-dimensional profiling model of this nature are required to assess critical determinants of performance over a longer period of time. A global research study utilizing a comprehensive multi-dimensional profiling model could help facilitate a greater understanding of the variables, which impact the attainment of expert performance in table tennis.

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Table 1. Descriptive Statistics

		M	*SD*	Min.	Max.
Age (years)		13.7	3.5	12	17
Anthropometry	Weight (kg)	53	16	40	70
	Standing height (cm)	160	41	150	180
	Sitting height (cm)	78	20	70	92
Age from peak height velocity (years)		0.13	1.55	-2.38	2.62
Motor skills	Eye hand coordination (correctly caught balls)	31	8	27	39
	Sprint (s)	27	7	34	24
Psychological skills					
Engagement	Vigor	4.3	1.0	2.3	6
	Dedication	4.8	0.9	2.7	6
	Absorption	4.3	0.6	3.3	5.3
Mental toughness		5.7	0.3	5	6.4
Sport motivation	Intrinsic Motivation	4.7	0.5	3.5	5
	Integrated Regulation	3.9	0.9	1	5
	Identified Regulation	4.1	0.6	2.5	4.8
	Introjected Regulation	2.9	1.3	1	5
	External Regulation	2.0	0.8	1	3.5
	Amotivation	1.7	1.2	1	5
Emotional regulation	Self-blame	3.6	0.9	2	5
	Acceptance	3.7	0.9	2	5
	Rumination	3.4	0.9	2	5
	Positive Refocusing	2.5	1.2	1	4.5
	Refocus on Planning	3.8	0.7	2.5	5
	Positive Reappraisal	3.7	0.8	2.5	5
	Putting into Perspective	3.4	0.9	1.5	5
	Catastrophizing	2.7	1.1	1	5
	Blaming Others	1.8	0.6	1	3
Self-regulation in	Reflection	4.1	0.4	3.4	4.8

learning	Evaluation	3.7	0.6	2.6	4.4
	Planning	2.8	0.6	2.3	3.5
	Self-monitoring	2.8	0.5	1.7	3.5
	Effort	3.2	0.3	2.8	3.7
	Self-efficacy	3.0	0.4	2.4	3.8
Training volume (hours)		2177	1518	864	5696
Training history (years)		5	2.2	3	10
Rating 2016 (points)		1354	290	815	1982
Rating 2017 (points)		1421	241	1009	1891
Progression 2016-2017 (points)		66	87	-91	194

Notes. *M = mean, SD = standard deviation, min. = minimum, max = maximum.*

Table 2. Significant Spearman Rank-Order Correlations between Multidimensional Assessment Outcomes and Performance Indicators.

		Rating 2016	Rating 2017	Progression 2016-2017
Maturity	APHV (years)	0.71^{*}	0.45	-0.77^{*}
Motor skills	Sprint (*seconds*)	-0.69^{*}	-0.44	0.63^{*}
Psychological skills	Positive Refocusing	-0.58^{*}	-0.58^{*}	0.12
	Evaluation	0.57^{*}	0.34	-0.58^{*}
	Self-monitoring	-0.60^{*}	$-0.50^{¥}$	0.69^{*}
Training history	Number of years	0.84^{*}	0.80^{*}	$-0.52^{¥}$

Notes. APHV = age from peak height velocity; $^{¥}P \leq 0.09$, $^{*}P < 0.05$.