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Explaining the performance of talented youth speed skaters

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EXPLAINING THE PERFORMANCE OF TALENTED YOUTH SPEED SKATERS

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ABSTRACT

This research investigated whether it is possible to explain the performance of talented youth speed skaters between the age of 15 to 20 years. Multidimensional performance characteristics were compared with the speed skating performance on separate distances (500 m, 1.000 m, 1.500 m and 3.000 m) and the allround performance, in the season of 2009-2010. Eight athletes from the Dutch national youth speed skating team (18-19 year old), along with 20 talented athletes from the Dutch district teams (15-17 year old) were included. Multidimensional performance characteristics consisted of anthropometrical, physiological, technical and psychological characteristics. Partial correlations were calculated between each performance characteristic and the speed skating performance, while controlling for gender and age. For the 500 m, jump height, measured as a squat jump ($r=-.664$) and countermovement jump ($r=-.619$), and the technique of the speed skaters ($r=-.500$) was found to be an explanation of the performance. For the 1.000 m this was only jump height, measured as a squat jump ($r=-.555$) and countermovement jump ($r=-.491$). The speed skating performance on the longer distances (1.500 m and 3.000 m) were found to be significantly related with evaluation ($r=-.420$ and $r=-.481$) and anaerobic power ($r=.409$ with the 3.000 m). The allround speed skating performance was significantly related with jump height, measured as a squat jump ($r=-.406$) and related with the technique ($r=-.541$). It can be concluded that explaining the performance of talented youth speed skaters is difficult. Nevertheless, this study reveals that jump height and technique seem to be important prerequisites for almost all distances.

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KEYWORDS: multidimensional performance approach; talent; adolescence.

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INTRODUCTION

While the world records are improving (Kuper & Sterken, 2003), the differences in performance between speed skaters are also becoming smaller at the top levels (Sierksma, 2009). This is shown by the many different winners in the international tournaments. In the 2009-2010 competitive season as much as 17 different male and 11 different female skaters won a distance on the 55 distances of three international tournaments (Olympic Games, World Championships, and World Cup). These included skaters from seven countries among which the Netherlands. Speed skating performance is not only important at senior levels. In order to keep the prominent role in speed skating, Dutch talented youth speed skaters need to focus on performance levels even above the current levels at the senior top. Selections for the district youth teams (13-17 years) or the national youth team (17-19 years) of the Dutch Skating Association (KNSB), are currently mainly based on the speed skating performance in national or international tournaments. Becoming part of this youth team is important, because it provides young talented speed skaters with outstanding training facilities and highly qualified trainers, which in turn, will likely further improve their performance (Baxter-Jones & Helmes, 1996; Helsen, Hodges, van Winckel, & Starkes, 2000). Understanding the underlying characteristics for speed skating performance is thought to aid young talented skaters' improvement in performance.

Speed skating is a competitive form of ice skating, where the speed skater has to cover a certain distance on a 400 m-oval ice track as fast as possible on skates. The usual distances are 500 m, 1.000 m, 1.500 m, 3.000 m, 5.000 m and 10.000 m. The 500 m and 1.000 m are regarded sprinting events, with the best considered strategy to just skate as fast as possible (Van Ingen Schenau, de Koning, & de Groot, 1990). During the 1.500 m an all out pace no longer gives the best results (Hettinga et al., 2009; Van Ingen Schenau et al., 1990), because early fatigue will most likely result in a loss of technique (i.e. less crouching position), which increases the air friction (De Koning, Foster, Lampen, Hettinga, & Bobbert, 2005). The 3.000 m, 5.000 m and 10.000 m are considered long distances with a relative large contribution of the aerobic energy system (Gastin, 2001). For these longer distances a constant power output, after an all-out start, seems the best strategy (Van Ingen Schenau et al., 1990).

It is likely that performance in speed skating is not explained by only one characteristic, but rather by multidimensional characteristics. Weaknesses in certain characteristics are often compensated by strengths in others, even at high performance levels (Williams & Reilly, 2000). A multidimensional approach has recently proven to be successful in explaining performance in other sports (e.g., Elferink-Gemser, Visscher, Richart, & Lemmink, 2004; 2007; Reilly, Williams, Nevill, & Franks, 2000; Williams & Reilly, 2000). The current study therefore adopted a multidimensional approach, with anthropometrical, physiological, technical, and psychological characteristics.

The main purpose of this study was to investigate whether it is possible to find multidimensional performance characteristics that explain the performance of talented youth speed skaters between 15 and 20 years. This is done by examining the relationship between multidimensional characteristics and the performance of young talented speed skaters on the 500 m, 1,000 m, 1,500 m and 3,000 m.

METHODS

Subjects

Subjects in this study were eight junior speed skaters from the national youth team of the KNSB (18-19 years) and 20 junior speed skaters from the district teams (15-17 years). All subjects were considered to be talented, since they were all competing at the highest competitive level of their age category. Measurements took place at the end of the skating season of 2009-2010. General speed skating characteristics of the speed skaters are shown in table 1. The older speed skaters participated in the Junior World Championship, the Dutch National Junior Championships (Allround or Distances) and the Junior World Cup. The younger speed skaters participated in the Dutch National Junior Championships (Allround or Distances) and included speed skaters who will join the Dutch National Junior Team in season 2010-2011.

Table 1. General speed skating characteristics related to age, speed skating experience, races per week, training sessions per week and number of training hours per week, of the speed skaters classified by age-group and gender (mean $\pm$ standard deviation).

	Men		Women	
	15-17 year (n=9)	18-19 year (n=3)	15-17 year (n=11)	18-19 year (n=5)
Age (years)	16.9 $\pm$ 0.7	18.9 $\pm$ 0.7	16.7 $\pm$ 0.6	19.0 $\pm$ 0.5
Speed skating experience (years)	7.9 $\pm$ 1.5	9.6 $\pm$ 4.2	8.6 $\pm$ 1.2	11.2 $\pm$ 1.5
Races (n-week ⁻¹)	1.0 $\pm$ 0.4	0.9 $\pm$ 0.1	1.0 $\pm$ 0.3 ^a	1.1 $\pm$ 0.2
Training (n-week ⁻¹)	6.7 $\pm$ 0.9 ^a	10.3 $\pm$ 3.1	6.5 $\pm$ 1.1	12.6 $\pm$ 1.3
Training (h-week ⁻¹)	13.4 $\pm$ 2.0 ^a	22.5 $\pm$ 8.7	10.9 $\pm$ 3.6	21.3 $\pm$ 5.2

^a One missing value.

Speed skating performance

The speed skating performance is measured as the time needed to cover a certain distance. The competition closest to the measurement date of the anthropometrical, physiological and psychological tests was used for the speed skating performance. For the older speed skaters (18-19 year old), these were the Junior World Championship in Moskou, the Dutch National Junior Championships (Allround or Distances), the Dutch National Championships or the Junior World Cup Finals in Berlin. For the younger speed skaters (15-17 year old), these were the Dutch Vikingrace, the Dutch National selection competitions, the Dutch National Junior Championships (Allround or Distances) or regional club competitions. The 5.000 m and 10.000 m were not included, because speed skaters in these age groups rarely skate these distances in a tournament. The speed skating performance was corrected for the ice rink on which the competition was held, using the estimated rink parameters calculated by Kamst (2010). The allround performance was calculated by expressing the competition times into the time needed to cover each 500 m (e.g. the time needed to cover the 1500 m would be divided by three), followed by adding the times together.

Anthropometric measurements.

The following measurements were used to measure the body size of the participants: body height, body mass and body mass index (BMI). The measurements for the body height and body mass were employed prior to the physiological measurements. The BMI was calculated using body height and the body mass ($BMI = \text{body mass} / \text{body length}^2$).

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Physiological measurements

Jump height was measured with a vertical jump test (MuscleLap Jump, Ergotest Innovation, Porsgrunn, Norway). The squat jump (SJ) was performed from a stationary semi-squatting position. The countermovement jump (CMJ) was performed with a countermovement, meaning the speed skater starts from a standing position, lowers in a squat position and immediately jumps as high as possible. In both condition the arms were not allowed to be used as support. Each condition was performed three times. The best result of each speed skater was used for analyses. The SJ (α and ICC=.97) and the CMJ (α and ICC=.98) are both considered reliable (Markovic, Dizdar, Jukic, & Cardinale, 2004). Mean and relative mean anaerobic power (W and $W \cdot \text{kg}^{-1}$) were measured with a Wingate-type 10 seconds sprint test on an ergometer (Ergomedic 894E Peak Bike, Monark Exercise, Varberg, Sweden). Mean power and relative mean power (adjusted for body weight, $W \cdot \text{kg}^{-1}$) were administered. The warm-up for the 10 seconds sprint test consisted of 10 minutes submaximal cycling, including three short-lasting bursts of high intensity cycling. A 40m-sprint was performed on an indoor 40m running-track. The warm-

up consisted of 10 minutes submaximal running, including stretching and a few short-lasting bursts of high intensity running. The speed skaters started separately from a crouching position, without starting blocks. Each speed skater was wearing a chip around their ankle, which measured the time needed to complete the track (Run ProChip System, Mylaps, Haarlem, Netherlands). After a short break of around 10-15 minutes, the speed skaters performed another 40m sprint. The best result was used for analyses (Nesser, Latin, Berg, & Prentice, 1996).

Technical measurements

Of the 28 speed skaters who participated in this research, 20 speed skaters took part in the Dutch National Junior Championship for distances. These speed skaters were filmed during their 1500 m race with two digital camera's. One camera was placed perpendicular to the sagittal plane of the speed skater, and one camera was placed in front of the speed skater, filming the frontal plane of the speed skater (see also Van Ingen Schenau & de Groot, 1983). The video was shown to two highly qualified speed skating trainers. These trainers were asked to judge the level of technique by a scale rating from 1 to 10, with "1" indicating an insufficient technique, and "10" indicating a perfect technique. In order to encourage them to think carefully before deciding which rating score to give, the trainers were asked to motivate their judgment.

Psychological measurements

The six aspects of self-regulation were examined using the questionnaire described by Toering et al. (2009). On the subscales "planning", "self-monitoring", "effort" and "self-efficacy" the speed skaters needed to rate each item on a 4-point Likert-scale, and a 5-point Likert-scale on the subscales "evaluation" and "reflection". Scores on the subscale "reflection" were reversed, resulting in high scores for all subscales indicating high levels of self-regulation. The internal consistence (Cronbach's alpha) for the subscales were acceptable (α ranged from .74 for "self-monitoring" to .87 for "effort") (Toering et al., 2009). Sport motivation was measured by the Sports Motivation Scale (SMS) (Pelletier et al., 1995), translated in Dutch. This questionnaire measured intrinsic motivation, extrinsic motivation and amotivation in sports. Each item consisted of a 7-point Likert-scale. High scores on "intrinsic motivation" and "extrinsic motivation" indicate a high sports motivation, while high scores on "amotivation" indicate a low sports motivation. The SMS has an internal consistency which varied between .63 and .80 (Pelletier et al., 1995). Goal orientation was measured using a Dutch Task and Ego Orientation in Sport Questionnaire (TEOSQ) (Van-Yperen & Duda, 1999). This questionnaire measured task and ego orientation. The speed skaters had to answer on a 5-point Likert-scale. High scores on one of these subscale indicate a high task or ego orientation. Van Yperen & Duda (1999) reported an internal consistency of .82 for ego orientation, and .84 and .88 for task orientation.

Data analysis

Data were analysed using SPSS 16.0 (SPSS Inc. Chicago, IL). Mean scores and standard deviations for the multidimensional performance characteristics were calculated separately for male and female younger (15-17) and older (18-19) talented speed skaters. Also effect sizes were calculated between the male and female younger and older speed skaters using the cohen's d (Cohen, 1992). Differences between the younger and older speed skaters were tested using the Mann Whitney U test (one tailed). Partial correlations were calculated for each distance between the multidimensional performance characteristic and the speed skating performance, controlling for gender and age. Missing values were excluded pairwise. Statistical significance was accepted at $p < .05$.

RESULTS

Speed skating performance

The performance of the skaters (expressed in mean time (mm:ss.ss) and standard deviation) and effect sizes, are shown in table 2. The older male speed skaters outperform the younger male speed skaters on the 500 m, 1.000 m and allround performance, and seem to outperform the younger speed skaters on the 1.500 m and 3.000 m. The older female speed skaters outperform the younger female speed skaters on all distances. Effect sizes were large for all distances, ranging from 0.82 (male speed skaters on the 3.000 m), to 3.20 (female speed skaters on the 1.000 m).

Table 2. Speed skating performance (in mm:ss.ss) of the 15-17 and 18-19 year old speed skaters classified by gender and age (mean $\pm$ standard deviationa).

	Men		d ^b	Women		d ^b
	15-17 year (n=9)	18-19 year (n=3)		15-17 year (n=11)	18-19 year (n=5)	
500 m	00:38.34 $\pm$ 0.53	00:37.17 $\pm$ 0.10	2.65 ^c	00:41.61 $\pm$ 0.47	00:40.04 $\pm$ 0.67	3.14 ^c
1.000 m	01:15.65 $\pm$ 1.50	01:12.78 $\pm$ 0.73	2.27 ^c	01:22.33 $\pm$ 1.15	01:18.81 $\pm$ 1.26	3.20 ^c
1.500 m	01:56.37 $\pm$ 2.67	01:53.11 $\pm$ 2.77	1.29	02:06.71 $\pm$ 1.71	02:02.37 $\pm$ 1.21	2.94 ^c
3.000 m	04:03.77 $\pm$ 5.89	03:59.46 $\pm$ 5.05	0.82	04:32.94 $\pm$ 6.46	04:23.00 $\pm$ 8.16	1.52 ^c
Allround performance ^d	155.35 $\pm$ 2.79	151.18 $\pm$ 1.84	1.74 ^c	169.20 $\pm$ 4.18	164.07 $\pm$ 2.05	1.48 ^c

^aStandard deviations are in seconds. ^bd= effect size calculated with Cohen's d, d=0.20 (small), d=0.50 (moderate), d=0.80 (large)(Cohen, 1988). ^cSignificant difference between the younger and older speed skaters ($p < .05$). ^dScores are shown in points $\pm$ standard deviation.

The correlations between the speed skating performances on each distance are shown in table 3. The 500 m correlates significantly with the 1.000 m ($r=.733$), the 1.500 m ($r=.439$) and the allround performance ($r=.672$). The 1.000 m correlates significantly with 500 m, the 1.500 m ($r=.495$) and the allround performance ($r=.761$). The 1.500 m correlates significantly with the 500 m, 1.000 m, the 3.000 m ($r=.572$) and the allround performance ($r=.822$). While the 3.000 m only correlates significantly with the 1.500 m and the allround performance ($r=.777$).

Table 3. Partial correlation among speed skating performances ($df=24$) while controlling for gender and age.

	500m	1000m	1500m	3000m	Allround performance
500m	-	-	-	-	-
1000m	.733 ^a	-	-	-	-
1500m	.439 ^a	.495 ^a	-	-	-
3000m	.173	.304 ^b	.572 ^a	-	-
Allround performance	.672 ^a	.761 ^a	.822 ^a	.777 ^a	-

^aSignificant correlation between the speed skating performances ($p < .05$). ^bTrend with the speed skating performance ($p < .15$).

Multidimensional performance characteristics

The scores of the younger (15-17 year old) and older speed skaters (18-19 year old) of the multidimensional performance characteristics are shown in table 4, separated for men and women. The older male speed skaters seemed to be taller and heavier, compared with the younger male speed skaters, with effect sizes of at least 0.80. Both male and female older speed skaters were to be able to jump higher and skate with a better technique, compared with the younger speed skaters. The older male and female speed skaters also seemed to produce a higher power output (expressed in Watt) compared with the younger speed skaters. The older male speed skaters scored higher on "reflection" compared with the younger speed skaters and seemed to score higher on "planning", "self-monitoring", "evaluation" and "self-efficacy". The older female speed skaters however seemed to scored lower on "reflection". All male and female speed skater scored high on "intrinsic motivation", "task orientation" and "ego orientation", with average scores in the highest category of the Likert-scale. The older male speed skaters scored lower on "extrinsic motivation" and seemed to score higher on "intrinsic motivation", "task orientation" and "ego orientation", compared with the younger speed skaters. The older female speed skaters seemed to score higher on "amotivation" and "ego orientation", but scored lower on "intrinsic motivation", compared with the younger female speed skaters.

Table 4. Descriptive statistics of the multidimensional performance characteristics of the 15-17 and 18-19 year old speed skaters classified by gender and age group (mean $\pm$ standard deviation).

	Men		d ^e	Women		d ^a
	15-17 year (n=9)	18-19 year (n=3)		15-17 year (n=11)	18-19 year (n=5)	
Anthropometrical characteristics						
Body height (cm)	184.6 ± 8.0	189.8 ± 0.8	0.80	171.8 ± 4.2	171.0 ± 5.7	-0.19
Body mass (kg)	75.9 ± 5.9	82.3 ± 0.8	1.33	64.0 ± 3.5	66.1 ± 6.1	0.50
Body mass index	22.3 ± 1.7	22.8 ± 0.4	0.37	21.7 ± 1.4	22.6 ± 1.2	0.69
Physiological characteristics						
Jump Height (cm) (SJ) ^c	37.4 ± 5.0	46.5 ± 7.1	1.82	29.8 ± 4.5	38.9 ± 3.3	2.33 ^b
Jump Height (cm) (CMJ) ^d	38.8 ± 4.4	49.7 ± 9.2	2.10 ^b	30.6 ± 4.2	38.6 ± 4.6	1.98 ^b
Peak anaerobic power (W)	1731 ± 141.5	1910 ± 143.0	1.38	1224 ± 92.5	1316 ± 147.0	0.89
Relative peak anaerobic power (W/kg-1)	22.7 ± 1.4	23.2 ± 2.0	0.34	18.9 ± 1.6	20.0 ± 1.8	0.70
40m-Sprint (s)	6.0 ± 0.1 ^e	5.9 ± 0.1 ^e	-0.54	6.4 ± 0.2 ^e	6.3 ± 0.2 ^e	-0.55
Technical characteristics						
Technique rating score	8.1 ± 0.31 ^e	8.8 ± 0.35 ^e	2.47 ^b	7.5 ± 0.63 ^e	8.5 ± 0.54 ^e	1.80 ^b
Psychological characteristics						
Self-regulation						
Planning (scale 1-4)	2.8 ± 0.4	3.2 ± 0.2	1.01	3.2 ± 0.5	3.0 ± 0.4	-0.32
Self-Monitoring (scale 1-4)	2.9 ± 0.5	3.3 ± 0.3	1.14	3.1 ± 0.5	2.9 ± 0.1	-0.46
Evaluation (scale 1-5)	3.7 ± 0.4	4.0 ± 0.3	0.97	3.8 ± 0.3	3.8 ± 0.4	0.00
Reflection (scale 1-5)	3.8 ± 1.0	4.7 ± 0.2	1.17 ^b	4.3 ± 0.4	4.0 ± 0.4	-0.87
Effort (scale 1-4)	3.1 ± 0.5	3.2 ± 0.5	0.31	3.5 ± 0.4	3.3 ± 0.4	-0.63
Self-Efficacy (scale 1-4)	3.3 ± 0.4	3.6 ± 0.2	1.17	3.1 ± 0.4	3.1 ± 0.2	0.03
Sports motivation						
Intrinsic motivation (scale 1-7)	6.0 ± 0.6 ^e	6.6 ± 0.3 ^e	1.17	6.6 ± 0.4 ^e	6.0 ± 0.5 ^e	-1.44 ^b
Extrinsic motivation (scale 1-7)	4.9 ± 0.8 ^e	3.9 ± 0.1 ^e	-1.55 ^b	3.5 ± 0.8 ^e	3.4 ± 1.0 ^e	-0.13
Amotivation (scale 1-7)	1.7 ± 0.6 ^e	1.4 ± 0.7 ^e	-0.50	1.3 ± 0.5 ^e	2.0 ± 1.4 ^e	2.00
Goal orientation						
Task orientation (scale 1-5)	4.0 ± 0.7	4.6 ± 0.5	0.91	4.7 ± 0.3 ^e	4.5 ± 0.5 ^e	-0.72
Ego orientation (scale 1-5)	4.4 ± 0.3	4.7 ± 0.5	0.93	4.0 ± 0.6 ^e	4.5 ± 0.4 ^e	0.84

^ad = effect size calculated with Cohen's d, d=0.20 (small), d=0.50 (moderate), d=0.80 (large) (Cohen, 1988). ^bSignificant difference between the younger and older speed skaters ($p < .05$). ^cSquat jump. ^dCounter movement jump. ^eOne or more missing values.

The partial correlations (r) between the multidimensional performance characteristics and the speed skating performance are shown in table 5. Gender and age are included as controlling variables. No significant correlations have been found for the anthropometrical characteristics. The correlations were weak to moderate (r ranging between $-.183$ and $.236$). For the physiological characteristics the jump height (both SJ and CMJ) has a significant correlation with the speed skating performance on the 500 m ($r = -.664$ and $r = -.619$), the 1.000 m ($r = -.555$ and $r = -.491$) and overall performance (only SJ with $r = -.406$). Relative anaerobic power seemed to correlate with the 500 m ($r = -.294$) and correlated significantly with the 3.000 m ($r = .409$). The 40m-sprint seemed to correlate with the 500 m ($r = .413$), but was not significant. The technique correlate significantly with the performance on the 500 m ($r = -.500$) and the allround performance ($r = -.541$). The correlations between the technique and the 1.000 m ($r = -.430$), the 1.500 m ($r = -.281$) and 3.000 m performance ($r = -.432$) are moderately to high. For the psychological characteristics only evaluation, an aspect of self-regulation, correlates significantly with the speed skating performance on the 1.500 m and 3.000 m ($r = .420$ and $r = .481$) and seemed to correlate with the allround performance ($r = .374$). The rest of the psychological characteristics correlate low to moderately on the performance (r ranging between $-.303$ and $.261$).

DISCUSSION

The main purpose of this study was to investigate whether it is possible to find multidimensional performance characteristics that explain the performance of talented youth speed skaters between 15 and 20 years.

The distances used for investigating the speed skating performance are the 500 m, the 1.000 m, the 1.500 m and the 3.000 m, along with an allround performance. The 1.500 m correlates most with the allround performance, which means that when a speed skater is able to perform well on a 1.500 m distance, he or she will likely perform well on the other distances too (or the other way around). This supports the findings of Van Ingen Schenau and his colleagues (1990; 1996) who stated that the 1.500 m is often judged as the key distance for allround speed skaters. A speed skater who performs well on a 3.000 m however, will most likely perform less on a 500 m (or the other way around), since these distances have a low correlation. This low correlation is probably explained by the fact that the relative contribution of the anaerobic and aerobic energy systems is different for the 500 m, compared with the 3.000 m (Van Ingen Schenau et al., 1990). The older male and female speed skaters (18-19 years old) seemed to perform better on all distances, compared to the younger speed skaters (15-17 years old). This suggests that the performance level increases in time between 15 and 20 years.

Table 5. Partial correlations between the multidimensional performance characteristics and the speed skating performances while controlling for gender and age.

	500m	1000m	1500m	3000m	Allround performance
Anthropometrical characteristics					
Body height (df=24)	-.052	-.085	-.095	-.136	-.133
Body mass (df=24)	.143	-.044	-.115	-.179	-.097
Body mass index (df=24)	.236	.041	-.014	-.063	.038
Physiological characteristics					
Jump height (SJ) ^c (df=23)	-.664 ^a	-.555 ^a	-.210	-.065	-.406 ^a
Jump height (CMJ) ^d (df=23)	-.619 ^a	-.491 ^a	-.214	-.014	-.353 ^b
Peak anaerobic Power (W) (df=24)	-.089	-.064	-.080	.267	.110
Relative peak anaerobic power (W·kg ⁻¹) (df=24)	-.294 ^b	-.070	.171	.409 ^a	.152
40m-Sprint (df=21)	.413 ^b	-.139	-.171	-.185	-.019
Technical characteristics					
Technique rating score (df=16)	-.500 ^a	-.430 ^b	-.281	-.432 ^b	-.541 ^a
Psychological characteristics					
Self-regulation					
Planning (df=24)	-.011	.011	.109	.199	.128
Self-Monitoring (df=24)	.081	.240	.261	.034	.183
Evaluation (df=24)	-.149	.200	.420 ^a	.481 ^a	.374 ^b
Reflection (df=23)	.084	.040	.013	.004	.037
Effort (df=24)	.064	.177	.245	.041	.160
Self-Efficacy (df=24)	-.190	.035	.188	.135	.083
Sports Motivation					
Intrinsic motivation (df=20)	-.036	.149	-.010	-.116	-.023
Extrinsic motivation (df=20)	.066	.212	-.035	-.043	.037
Amotivation (df=20)	-.127	.157	.234	.305	.231
Goal orientation					
Task orientation (df=20)	.037	.133	-.214	-.177	-.100
Ego orientation (df=20)	-.303	-.076	-.271	-.119	-.234

^aSignificant correlation with speed skating performance ($p < .05$). ^bTrend with the speed skating performance ($p < .15$). ^cSJ = Squat jump. ^dCMJ = Counter movement jump.

The speed skaters participating in this research were eight members of the Dutch national youth team, along with 20 members of the district teams of the KNSB, who were nominated for the national youth team. This means that they were all competing at the highest competitive level of their age category. The difference between the average performance of the younger speed skaters and the current junior world record holders is less than 10.5 % (except for the 3.000 m ladies, which is 13.4%) (ISU, 2010). For the older speed skaters this difference is even less than 7.5% (except for the 3.000 m ladies, which is 9.3%). The difference in performance is even less, when you consider the influence of altitude (Kamst, 2010; Van Ingen Schenau et al., 1990; Van Ingen Schenau & Cavanagh, 1990). It can be argued that the group of speed skaters used in this research is too homogeneous and too small in numbers relative to the number of variables to be able to draw firm conclusions. This research, however, included already every speed skater that is currently participating in the Dutch national youth team. In order to increase the power of the results, this research also included the speed skaters who might have a chance to reach the Dutch national youth team.

The high scores on the performance characteristics confirm the high performance level of the speed skaters. Only the scores on the 40m-sprint seem to be relatively low. When comparing the male speed skaters with college men on the 40m-sprint test, the younger and the older male speed skaters were unable to surpass the performance of the college men (6.0 s and 5.9 s versus 5.9 s) (Nesser et al., 1996). The younger and older female speed skaters underperformed compared with elite female athletes between the age of 16-18 years (6.4 s and 6.3 s versus 5.9 s) (Steffen, Bakka, Myklebust, & Bahr, 2008). Together with the lack of significant correlations between then 40m-sprint and the speed skating performance, this suggests that a good 40m-sprint performance might not be a prerequisite for speed skating. Another interesting finding is that the older female speed skaters seem to use less self-regulatory skills, compared with the younger female speed skaters. This is in contrast with what Jonker and colleagues (2010) and Toering and colleagues (2009) found. Considering that both studies did not account for possible difference between male and female athletes, these findings might suggest that female speed skaters differ from male speed skaters in self-regulatory skills during the period between 15 and 20 years.

When looking at the correlations, only two characteristics were able to explain the all-round performance of speed skaters between the age of 15-20 years, namely jump height (SJ) and technique. This means that speed skaters with a higher explosive power and a better technique will perform better in speed skating. When looking at the distances separately, only two characteristics were able to explain the performance on the 500 m, namely jump height (SJ or CMJ) and technique. Only jump height explained the 1.000 m performance. This means that speed skaters with a higher explosive power will perform better on the 500 m and 1.000 m and speed skaters with a better technique will perform better on the 500 m, of both male and female speed skaters from the age of 15-20 years. Strangely at first, only the 3.000 m is related to relative anaerobic power. One would conclude, according to Gastin

(2001), that the relative contribution of the anaerobic energy system is low for an all out exercise of around 4 minutes (less than 21%). However the positive correlation indicates that the best 3.000 m speed skaters score low on relative anaerobic power. This indicates that the anaerobic energy system is relatively unimportant on the 3.000 m, and is in accordance with the results of Gastin (2001). The relation between evaluation, which is an aspect of self-regulation, and the speed skating performance might indicate that speed skaters who do not perform as good as their peers, evaluate their performance more extensively in order to find out as to why they do not perform as good. However, why this relation was not found for the other self-regulatory skills is unknown, and should be further investigated.

A limitation of this study was the use of self-report questionnaires for the psychological characteristics. Self-report questionnaires are generally sensitive to social desirable answers (Ericsson, Krampe, & Teschroemer, 1993) and give only insight into how speed skaters judge themselves on the psychological characteristics. How the self-regulation affects the behavior of the speed skaters, is still unknown, and should be further investigated. Furthermore, technical characteristics are based on the opinion of others, which could be biased. Although the trainers who judged the technique of these speed skaters were instructed to judge the technique objectively and had no interest in the outcomes of this study, determining the technique with the use of a motion analyzer would result in more objective data. Also, in this study speed skating performances from different competitions were used as a comparison. These performances were corrected for the ice rink on which the competition was held. Nevertheless, other factors such as ice condition and local air pressure also have a considerable effect on the performance (Van Ingen Schenau et al., 1990). Future research should, when possible, take these differences into consideration.

By investigating the development of the multidimensional performance characteristics that explain the performance over several seasons, it might become possible to predict who of the young speed skaters has a greater chance to become successful in adulthood, in which we are still not very successful (De Koning, Bakker, de Groot, & van Ingen Schenau, 1994). Because factors such as maturation have an impact on performance development, caution has to be taken on the assumption that performance of speed skaters between the age of 13-20 years can be extrapolated to performance during senior levels (Vaeyens, Lenoir, Williams, & Philippaerts, 2008). The mean age of peak height velocity (PHV), a valid benchmark for maturity (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002), lies around 13.8 years for boys (Philippaerts et al., 2006), and around 12.0 years for girls (Geithner, Woynarowska, & Malina, 1998). This makes it reasonable that before the age of 14 the performance characteristics of speed skaters are highly instable and do not represent the factors needed for performance at the senior top.

In summary, this research has shown that only jump height, either performed as a squat jump or a countermovement jump, is an important requisite for the sprint distances (500 m

and 1.000 m) for talented speed skaters between the ages 15 and 20. Next to these physiological requirements, a good technique is also one of the requirements for delivering a good allround performance, but especially for the sprint distances. Speed skating performance on the longer distances (1.500 m and 3.000 m) was found to be related with relative anaerobic power and evaluation, an aspect of self-regulation. It can be concluded that the performance level of the speed skaters between the ages 15-20 years, who are currently selected for the Dutch national junior team, and who are nominated for this team, is high. These high performances attend with small differences in performance and in the performance characteristics between the speed skaters. This makes it difficult in concluding which of the multidimensional performance characteristics explain the performance of these talented speed skaters.

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