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Original article

Does the McNeill Alexander model accurately predict maximum walking speed in novice and experienced race walkers?

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Running head: Predicting maximum velocity in race walking

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Abstract

Background: Mathematical models propose leg length as a limiting factor in determining the maximum walking velocity. This study evaluated the effectiveness of a leg length-based model in predicting maximum walking velocity in an applied race walking situation, by comparing experienced and novice race walkers during conditions where strictly no flight time (FT) was permitted and in simulated competition conditions (i.e., FT $\leq$ 40 ms).

Methods: Thirty-four participants (18 experienced and 16 novice race walkers) were recruited for this investigation. An Optojump Next system (8 m) was used to determine walking velocity, step frequency, step length, ground contact time, and FT during race walking over a range of velocities. Comparisons were made between novice and experienced participants in predicted maximum velocity and actual velocities achieved with no flight and velocities with FT $\leq$ 40 ms. The technical effectiveness of the participants was assessed using the ratio of maximum velocity to predicted velocity.

Results: In novices, no significant difference was found between predicted and maximum walking speeds without flight time but there was a small 5.8% gain in maximum speed when FT $\leq$ 40 ms. In experienced race walkers, there was a significant reduction in maximum walking speed compared with predicted maximum ($p < 0.01$) and a 11.7% gain in maximum walking speed with FT $\leq$ 40 ms.

Conclusion: The analysis showed that leg length was a good predictor of maximal walking velocity in novice walkers but not a good predictor of maximum walking speed in well-trained walkers who appear to have optimised their walking technique to make use of non-visible flight periods of less than 40 ms. The gain in velocity above predicted maximum may be a useful index of race walking proficiency.

Keywords: Biomechanics; Gait; Mathematical modelling; Race walking; Sports technique; Technique development.

1. Introduction

Race walking is a highly technical sport that features in most major athletic championships worldwide. It was introduced into the Olympic Games in 1908 as a standalone event and the primary distances currently used in competition are 20 km and 50 km. Due to the high technical demands of the event, race walkers are constantly monitored during races to ensure they adhere to the rules. The rules as outlined by the International Association of Athletics Federations (IAAF) state that, "race walking is a progression of steps taken so that the walker makes contact with the ground, so that no visible (to the human eye) loss of contact occurs. The advancing leg must be straightened (i.e., not bent at the knee) from the moment of first contact with the ground until the vertical upright position".[1] Therefore the rule can be divided into 2 main components, contact with the ground and knee straightness. When a judge observes an athlete breaking either component of the rule, the athlete receives a red card which is reported to the chief judge. If an athlete receives 3 red cards from 3 separate judges, this results in disqualification from the race. Currently in international competitions, the judging relies on subjective human observation which naturally introduces the capacity for human error.[2, 3]

Race walkers are trained to overcome the body's natural reaction to run, which is a more economical form of movement at higher velocities.[4, 5] More recent studies have shown that transitioning from walking to running results in an increase in energy expenditure[6] and the point at which the walk-run transition occurs in untrained race walkers is thought to be influenced by the plantarflexor and dorsiflexor muscles. This transition of gait occurs to prevent the dorsiflexor muscles from being over-exerted.[7] There is evidence that at walking speeds close to the preferred walk-run transition, poor contractile conditions may necessitate a change in gait [8] while peak and mean plantar pressures were found to be significantly higher during race walking compared to normal walking.[9] Consequently, race walkers use a unique walking gait to optimise speed while still adhering to the rules.

Various models have been proposed to explain the biomechanical limitations on walking speed.[10, 11] Most of these models indicate that leg length is the primary limiting factor in determining the maximum velocity a race walker may achieve within the rules, (i.e., before lifting occurs). McNeill Alexander[11] proposed a mathematical model for predicting the maximum velocity (v_{pred}) of an individual adhering to the rules, i.e., when no flight time (FT) is allowed. This model proposes that the leg acts as an inverted pendulum of length (L), and the maximal walking speed of an individual is determined by Eq.1.

$$v_{\text{pred}} = \sqrt{g.L} \quad \text{(Eq. 1)}$$

Where, g = gravitational acceleration (9.81 m/s) and L is the length of the leg which in practice may refer to the length of the leg from the iliac crest to the ground, including the height of the shoe. Therefore, an individual with an effective leg length of 0.90 m will achieve a predicted maximum velocity of 2.97 m/s during race walking.[11, 12] Inspection of official performances in international competition indicates that race walkers achieve much higher walking speeds without disqualification. For example, the average speed recorded at a typical IAAF race was 4.03 ± 0.239 m/s for men and 3.54 ± 0.272 m/s for women;[13] this would require effective leg lengths of 1.66 m and 1.28 m, respectively (since $L = v_{pred}^2/g$). There are 2 likely explanations for this: firstly, race walkers employ techniques to alter the biomechanics of walking and facilitate greater velocities[14] and/or secondly, they lose contact with the ground for short periods which are undetectable by the methods currently employed by the IAAF judges. McNeill Alexander[15] proposed that the compensatory hip movements used by experienced race walkers may provide an explanation for this increased velocity; by lowering the center of mass using compensatory hip movements, the center of mass travels in a flatter arc (i.e., an arc of greater radius). The radius of this arc is greater than leg length and thus enables higher speeds to be attained. By calculating the race walker's predicted maximum speed and then establishing their maximum speed achieved within the rules of race walking, it may be possible to get an indication of their technical proficiency.

It has been proposed that human eye can only process images at a maximum rate of approximately 16 Hz (i.e. that last longer than 60 ms) [2] and any event of shorter duration than this will not be processed accurately by the observer. Knicker and Loch[3] established that the mean FT during phases of lifting in race walking was 46 ms and mean FTs for those for those not identified was 39 ms. This was further reinforced by De Angelis and Menchinelli[16] who found that when analysed by a coach of long-standing international experience, the athlete was seen to be lifting when FT approached and/or exceeded 40 ms. More recently, Hanley et al.[17] examined elite race walkers walking at their typical competition speeds and observed FTs of 30 ± 11 ms (mean ± SD),which suggests that some walkers used FTs > 40 ms. Practically, this means that race walkers could use FTs of approximately 40 ms to increase their race walking velocity when competing which is higher than their predicted maximum velocity.

Based on the above, there appears to be merit in evaluating whether the McNeill Alexander[11] model provides a valid prediction of maximum race walking speed in both trained and experienced race walkers as this could provide insights into the technical proficiency of race walkers. Recent research has demonstrated that elite race walkers achieve velocities in competition and training far greater than those predicted by McNeill Alexander's model and that up to 10% of the velocity achieved by elite race walkers accrues from the flight phase.[18] It is likely that FTs of ≤40 ms will be undetected in competitions[3] therefore, an evaluation of maximum walking speed should consider situations where the ground contact rule is strictly enforced and when a FT of ≤40 ms is used. Consequently, the aim of this study was to experimentally evaluate the validity of the McNeill Alexander[15] model in predicting the maximum walking velocity in a practical setting. This can be done by comparing experienced and inexperienced race walkers under conditions of no FT and in simulated competition conditions where a FT of ≤40 ms was permitted. The data could potentially be used to assess the effectiveness of an athlete's technique by comparing predicted speed with maximum speed achieved in simulated competition conditions (i.e., FT ≤40 ms). The ratio of predicted to maximum speed achieved could provide a useful index of technical proficiency.

2. Materials and methods

2.1. Participants

Following University Ethical Committee approval, 34 participants were recruited for this investigation. This included 16 individuals (14 males and 2 females) with no prior race walking experience (novice group; age: 21.0 ± 2.61 years; height: 1.76 ± 0.06 m; mass: 73.8 ± 9.6 kg) and 18 competitive "experienced" race walkers (7 males and 11 females) who were members of a national development squad (experienced group; age: 16.80 ± 2.46 years, height: 1.68 ± 0.06 m, mass: 56.6 ± 7.4 kg). All participants provided written informed consent to participate in this study and where participants were under 18 years, parental consent was also obtained. All participants were injury free at the time of testing.

2.2. Experimental protocol

The vertical height from the ground to the participant's iliac crest while standing in the shoes they wore for all trials was measured using a flexible steel tape measure. This measure provided the effective leg length for the prediction of maximum walking speed using the McNeill Alexander model[11]. This method was preferred to measurement of the height to greater trochanter since it provides a closer approximation of the height of the center of mass and represents the effective leg length for the predictive model. Furthermore, the measure was considered superior due to known lack of reliability and accuracy in palpation of the greater trochanter particularly in female participants.

The test area was 8 m long by 1 m wide with dual-beam timing gates (Microgate, Bolzano, Italy) set up at both ends. The timing gates were positioned at average pelvis height to measure the speed of the participant during each trial. An LED based gait analysis system (Optojump Next, Microgate, Bolzano, Italy) was positioned with 8 m of transmitter and receiver rails set at 1 m apart running parallel to the direction of movement, to determine ground contact time, FT, step length and step frequency. The reproducibility of photocell-based measurements and their concurrent validity against gold standard methods such as force platforms and high-frequency video cameras, are well established [19]. Each trial was also recorded using a single 300 Hz Casio EX-FX1video camera (Casio Computers Co Ltd., Tokyo, Japan) positioned perpendicular to the plane of motion and 4 halogen lamps were used for additional illumination of the test area. The compliance of each participant to IAAF rules of race walking [1] was determined by an experienced coach, but a secondary retrospective visual check of sagittal plane leg straightness during ground contact was obtained using the 300 Hz video records.

Participants were encouraged to complete their own warm-up, which typically included light cardiovascular exercise and dynamic stretching. Multiple trials were conducted and participants were instructed to walk through the test area which was set up near the end of a straight section of a looped course with straights approximately 30 m. This allowed the participants to attain a stable walking speed before entering the 8 m measurement zone. The participants were asked to gradually increase their walking speed on each trial and focus on walking within the IAAF rules[1]. Initial trials were conducted at a slow pace (typically 1 to 1.5 m/s) and progressively increased in speed. The novice walkers required frequent reminders to walk without flexing their knee during the ground contact phase. Testing was concluded when either the participants felt they could not go any faster without breaking the straight knee or ground contact rule, or breaches of the rules were detected by the observer, or no further increases in walking speed were measured by the timing gates. Maximum walking speed was achieved within 6-10 trials for each participant.

2.3. Data analysis

The potential maximum walking speed for each participant was calculated from the effective length of the individual leg using McNeill Alexander's[15] equation (Eq. 1). The observed maximum speed achieved under 2 conditions was used for analysis. Condition 1 was defined as the maximum speed obtained with no FT detected using Optojump (FT = 0 ms condition). Condition 2 was defined as the maximum speed obtained when a FT of maximum 40 ms was allowed based on Optojump data (FT ≤ 40 ms condition). Using Eqs. 2 and 3 the percentage increase/decrease was calculated and used as a means of determining the technical effectiveness (*TE*) of the participant's technique.

$$TE(\mathrm{FT} = 0\ \mathrm{ms}) = \left(\frac{v_{0\ \mathrm{ms}} - v_{\mathrm{pred}}}{v_{\mathrm{pred}}}\right) \times 100 \qquad \text{(Eq. 2)}$$

$$TE\ (\mathrm{FT}\ \leq 40\ \mathrm{ms}) = \left(\frac{v_{40\ \mathrm{ms}} - v_{\mathrm{pred}}}{v_{\mathrm{pred}}}\right) \times 100 \qquad \text{(Eq. 3)}$$

Where: $TE(FT = 0\ ms)$ is the technique effectiveness (%) with no FT allowed

$TE(\text{FT} \leq 40\text{ ms})$ is the technique effectiveness (%) with ≤ 40 ms FT allowed.

$v_{0\text{ ms}}$ is the maximum walking speed with no FT allowed.

$v_{40\text{ ms}}$ is the maximum walking speed with ≤40 ms FT allowed.

v_{pred} is the maximum predicted walking speed based on effective leg length.

To examine why a 40-ms "window" may be effective for race walkers, 3 novice walkers and 3 experienced walkers who achieved the greatest percentage increases in walking speed with FTs ≤40 ms relative to their predicted velocity (i.e., most technically effective) were identified for further analysis. The 3 experienced walkers with the lowest increase (least technically effective) were also included in this analysis. The least technically effective novice walkers experienced difficulty maintaining a straight leg without lifting and therefore could not be included in this comparison. Comparison of the differences in the gait parameters (step length, step frequency, ground contact time, and flight time) between the most effective and the least effective participants was used to indicate parameters that experienced and novice race walkers may use to maximize speed without disqualification.

2.4 Statistical analysis

All statistical analysis was conducted in SPSS Statistics Version 22.0 (IBM Corp., Armonk, NY, USA). Level of significance was set at $p < 0.05$ for all statistical analyses. The predicted maximum speed, maximum speed achieved with no FT, and maximum speed achieved with FT ≤ 40 ms for each individual was used for analysis. Group mean and standard deviation was calculated for each condition. Assumptions of normality and homogeneity of variance were assessed using Shapiro-Wilk's test and Levine's test. Repeated measures analysis of variance (RMANOVA) was used to identify differences between predicted and achieved maximum velocities in the 2 test conditions, and one-way analysis of variance used to determine between group differences. To establish practical significance, effect sizes were calculated using Cohen's effect sizes which express ratio of the mean of observed differences and the pooled standard deviation.[18] For between-group comparisons Cohen's d was used while within-group comparisons used Cohen's d_z. The scale for classification of effect size was: <0.2 = trivial, <0.6 = small, <1.2 = medium and >1.2 = large,[20] with medium and large effect sizes considered practically significant. Since the groups consisted of different numbers of males and females, a two-way RMANOVA with gender (2 levels: male and female) and velocity (3 levels: predicted maximum velocity, maximum velocity at FT = 0 ms, and maximum velocity at FT ≤ 40 ms) was computed to examine the interaction effect of gender × velocity.

3. Results

This RMANOVA analysis showed no statistically significant gender × velocity interaction effect (p = 0.07) and this justified the pooling of males and females in the subsequent analysis. The participant data demonstrated significant differences between the 2 groups for age, body mass, and height ($p < 0.05$). Despite the group difference in height, comparison of the effective leg length measures between novice and experienced walkers showed no statistically significant differences ($p = 0.69$; Cohen's $d = 0.13$, trivial), with mean effective leg lengths of 1.04 ± 0.06 and 1.04 ± 0.04 m (mean ± SD) for the novice and experienced groups, respectively.

Consequently, the results showed no significant difference between mean predicted maximum speeds for the novice and experienced groups (Table 1). Since age and body mass are not factors in the prediction model for walking speed and height differences did not result in effective leg length differences between groups, it is unlikely that the group differences in age, body mass, and height presented important limitations in this study. When no FT was allowed, the maximum walking speed achieved by the novice group was significantly greater than the experienced group. When an FT of ≤40-ms was allowed there was no statistically significant difference in maximum walking speeds between the novice and experienced groups.

Inspection of individual participant data showed that except for 1 participant, all experienced walkers achieved higher than their predicted maximum walking speed when a 40-ms FT was allowed, but only 7 of the 16 novices achieved greater than their predicted maximum speeds with a ≤40-ms FT. The speeds achieved when a ≤40-ms FT was allowed were equivalent to a 5.8% ± 18.0% and 11.7% ± 10.6% improvement from the predicted maximums for the novice and experienced groups, respectively. When comparing novice and experienced this mean percentage improvement in walking velocity with ≤40-ms FT was not statistically significant ($p = 0.25$; Cohen's $d = 0.45$, small).

Table 2 shows the within-group, pairwise comparisons amongst the 3 conditions (predicted maximum velocity, maximum velocity with no lifting, and maximum velocity with FT ≤ 40 ms). Absolute percentage change and effect sizes using Cohen's d_z are provided for these comparisons. Within the experienced group, the mean maximum velocity with no FT allowed was significantly lower than the predicted maximum velocity ($p < 0.01$). However, in the ≤40 ms FT condition, the experienced group achieved maximum walking speeds significantly faster than the predicted maximum ($p < 0.05$) and also significant faster than the no FT condition ($p < 0.05$). By contrast, the differences between predicted and no FT velocities for the novices were neither statistically or practically significant ($p = 0.26$). The difference between the predicted and ≤40 ms FT condition was significant but the effect size remained small ($p = 0.046$;) while the difference between the no FT and the ≤40 ms FT condition within the novice walkers was not statistically significant ($p = 0.08$).

Table 3 compares technical effectiveness of novice and experienced walkers when walking without lifting and with FTs ≤ 40 ms. Overall, the results show that experienced walkers obtained significantly better technical effectiveness scores when walking with FTs ≤ 40 ms but scored worse than novice walkers when no flight time was allowed.

Individual analysis of the 3 most technical effective novice walkers, the 3 most effective and 3 least effective walkers in the experienced group are provided in Table 4. This showed general trends of increased step length, increased step frequency, decreased contact time, and FTs closer to 40 ms in walkers who achieved the greatest percentage increases relative to predicted speeds, compared to those with smaller percentage improvements/decreases relative to predicted maximum walking speed.

4. Discussion

The aim of this study was to evaluate experimentally, the validity of the McNeill Alexander model[15] in predicting the maximum walking velocity in a practical setting. The results showed the model was a good predictor of maximal walking speed in novice walkers when no flight time was permitted, but it did not appear to be an accurate predictor of maximal walking speeds achieved by experienced race walkers in simulated competition conditions when a FT of ≤40 ms was allowed. The reasons for this appear to be related to the experienced walkers' manipulation of the stride parameters to achieve an undetected FT in a practical race walking situation.

The mean walking velocity of the experienced group was well below the average competition velocities achieved by elite walkers in other studies.[13, 16, 21-23] This may be explained by the wide range of ability within the experienced group and that overall, the group cannot be described as elite. In addition, the constraints of the measurement set up may not have allowed all walkers to achieve a fully stable walking pattern at competition speed, although it should be noted that none of the walkers suggested that this was a problem for them. It is also possible that some elite walkers achieve higher speeds in competition by having flight periods >40 ms,[17] since the 40 ms flight time used in this investigation represents an empirically based estimate of the duration of a visually undetectable flight time rather than a sharply defined threshold of detection. Observation of individual performance scores shows that the best participants in the experienced group achieved walking speeds of 3.91 to 4.22 m/s which are typical of elite performers. The results showed a significant difference between the mean maximum predicted velocity in the experienced group (3.19 m/s) and mean maximum velocity achieved with zero flight time (2.70 m/s) which indicates that experienced walkers began to lift before they achieved their predicted maximum walking velocity. This suggests that the experienced walkers may have adapted their walking patterns through practice, coaching and in response to judging in competition.[2,3] Race walkers are coached to adhere to the 2 primary rules of race walking through a process of walking normally and gradually introducing different aspects to the technique.[24,25] As they develop their technique and begin competing, the legality of their technique is judged by coaches in training and officials in competition. Since the human eye has a limited processing frequency of 16 Hz,[2] it is inevitable that very small FTs will pass undetected by coaches in training and judges in competition and this encourages and reinforces the walker to develop a walking pattern that employs a non-visible (in real time) flight phase. The results of this investigation showed that experienced walkers use this adapted walking style with flight phases ≤40 ms even at walking speeds slower than the predicted maximum walking speed. In the novice walkers, when a FT ≤40-ms was allowed, there was no statistically significant difference between the mean predicted velocity and the maximum velocity achieved (3.38 m/s). This highlights that the novice group benefitted only slightly from being allowed a FT ≤40 ms. When the experienced walkers were allowed a flight time ≤40 ms, the mean velocity achieved (3.56 m/s) was significantly greater that the predicted maximum, demonstrating that the experienced walkers used their technique to increase walking velocity without detection.

Qualitative inspection of the high speed video records of the participants showed that at near-maximum walking speeds, the novice walkers tended to bend the knee of their stance leg and only a few managed to achieve a flight phase. As part of the analysis process, any participants who could not keep their knee straight even at slow walking speeds were removed from subsequent analysis. The main difficulty for novice walkers appeared to be their tendency to bend the knee of their stance leg as the walking speed increased. The fact that several novice participants had to be removed from the analysis because they could not walk without bending their knee even at very slow speeds provides further evidence of the difficulties some learners may encounter when attempting perform the stereotypical race walking pattern. This can be attributed to the differences in motor programming/learning for walking and running in untrained walkers.[26] Through practice, the experienced participants had adapted their walking technique to keep their leg straight and adhere to the rules, but the novice walkers had more difficulty in retaining a straight leg as walking velocity increased.

The analysis of individual participant data in Tables 3 and 4 demonstrates the range of technical effectiveness exhibited by novice and well trained walkers. The technical effectiveness expressed as a percentage improvement of the maximum achieved walking speed with flight time ≤40 ms showed that experienced walkers achieved percentage improvements scores above the maximum predicted velocity ranging from 0 to 38%. The results show that the 3 most effective, experienced walkers had step length, step frequencies, and contact times that were consistent with those recorded in other studies.[13,16, 23] By contrast, the 3 least effective experienced walkers recorded lower step lengths, lower step frequency, or a combination of both. This indicates that their technique was unable to sustain them operating with higher step length and frequency. These data show that while all of the experienced walkers were in regular training and were members of a national development squad, some did not demonstrate proficient technique. The index of effectiveness as a percentage improvement on the predicted maximum speed has potential for identifying the technical proficiency in walkers irrespective of competition standard and could be used as a simple method of monitoring race walking techniques, improvement and could potentially be used for talent identification. The results of technique effectiveness analysis on the novice walkers showed that some of the best novice walkers had scores that were higher than some of the experienced walkers, which supports the application of this index in talent identification. Furthermore, the walking speeds achieved by the best novices were greater than many of the experienced walkers. This suggests that some of the novices had very good aptitude for race walking and with appropriate conditioning training may have the potential to do well in competition. Further research on the merits of this simple index of technical effectiveness via training intervention studies is recommended.

5. Conclusion

The results of this investigation showed that the McNeill Alexander model [11] is a valid predictor of maximal walking speed in most novice walkers. By contrast, the model was not a good predictor of maximum walking speed in well trained walkers who have adapted their walking technique to make use of flight periods ≤40 ms which are undetectable to the human eye. In experienced walkers, these short duration flight phases are observed even at relatively slow walking speeds. The ratio of maximum walking velocity with FT ≤40 ms to the predicted maximum velocity may provide a useful index of technical proficiency which can be used to differentiate between novice and experienced walkers. This index may also have potential for monitoring performance change or talent identification.

Authors' contributions

AJH conceived the study and its design, assisted in data collection, completed statistical analysis, drafted and revised the manuscript; PGM participated in the study design, collected and analysed data and helped to draft the initial manuscript; LAMF conceived the study, participated in its design, collected data and contributed to statistical analysis and revision of the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

None of the authors declare competing financial interests.

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Table 1. Maximum walking velocities of novice and experienced race walkers (mean ± SD).

	Group		p	d
	Novice	Experienced		
Predicted maximum velocity (m/s)	3.20 ± 0.10	3.19 ± 0.06	0.72	0.13
Maximum velocity FT = 0 (m/s)	3.22 ± 0.45	2.70 ± 0.14	<0.01	1.27
Maximum velocity FT ≤ 40 ms(m/s)	3.38 ± 0.53	3.56 ± 0.34	0.21	0.42

Table 2. Within-group pairwise comparisons across walking velocities in 3 conditions in novice and experienced race walkers.

Pairwise comparisons	Novice		Experienced	
	%change	Cohen's d_z	%change	Cohen's d_z
Predicted maximum *vs.* No FT	1.0	0.29 (small)	-15.2**	1.92 (large)
Predicted maximum *vs.* With FT ≤ 40 ms	5.8*	0.54 (small)	11.7*	1.57 (large)
No FT *vs.* With FT ⩽ 40 ms	4.9	0.47 (small)	26.9**	2.32 (large)

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

Abbreviation: FT = flight time.

Table 3. Comparison of mean technical effectiveness scores (%) for experienced and novice walkers without lifting and with ≤40 ms FT.

Technical effectiveness	Group		*p*	*d*
	Novice	Experienced		
No FT (%)	1.0 ± 14.9	-15.2 ± 5.2	<0.01	1.05 (m)
≤40 ms FT (%)	5.8 ± 18.0	11.7 ± 10.6	0.04	0.71 (m)

Abbreviation: FT = flight time.

Table 4. Step characteristics during practical race walking situation. Data presented from 3 novice walkers and 6 experienced race walkers with largest differences from predicted maximum velocities.

	Velocity predicted (m/s)	**Velocity FT ≤ 40 ms (m/s)**	**% change relative to predicted**	**Step length (m)**	**Step frequency (Hz)**	**Contact time (ms)**	**Flight time (ms)**
Best novices							
N1	3.15	3.88	23.0	1.22 ± 0.03	3.5 ± 0.11	292 ± 9	0
N2	3.13	4.21	27.5	1.20 ± 0.06	4.62 ± 0.37	184 ± 11	31 ± 12
N3	3.00	3.93	23.7	1.15 ± 0.04	3.42 ± 0.11	266 ±19	19 ± 9
Best experienced							
E1	2.98	4.12	38.1	1.20 ± 0.02	3.4 ± 0.14	263 ± 8	24 ± 1
E2	3.05	4.22	37.5	1.21 ± 0.01	3.5 ± 0.06	262 ± 5	27 ± 4
E3	3.04	3.91	28.6	1.24 ± 0.01	3.1 ± 0.05	284 ± 9	34 ± 8
Worst experienced							
E4	3.08	3.25	5.7	1.21 ± 0.02	2.6 ± 0.74	310 ± 6	14 ± 12
E5	3.11	3.19	2.5	1.10 ± 0.03	2.9 ± 0.09	327 ± 10	15 ± 6
E6	2.98	2.95	-0.9	1.01 ± 0.02	2.9 ± 0.07	325 ± 6	11 ± 8