Effectiveness of Popular Race Walking Drills in Activating Key Muscles

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ABSTRACT

Race walking is a technical event where coaches frequently use event-specific drills to develop their athletes' strength and movement skills in training. The purpose of this study was to measure the effectiveness of six drills often used by race walkers because of their value in activating key muscles. The muscle activity of eight lower limb muscles was measured using electromyography in 10 young race walkers as they completed the six drills down a biomechanics runway. Two force plates were used to measure contact times and flight times, and the results were compared to the muscle activity recorded during normal (competition-paced) race walking. In general, the drills chosen for analysis achieved greater activation of the key muscles of the gluteus maximus, rectus femoris and vastus lateralis; however, they were not as beneficial with regard to the activity of biceps femoris and tibialis anterior, two muscles that are often injured in race walking. Coaches are advised to ensure that drills used in training are specific to their athletes' needs and do not inadvertently lead to non-legal technique (e.g., through increased flight time).

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Introduction

Race walking is a highly technical endurance event where it is vital for competitors to achieve and maintain a specific gait to avoid disqualification under IAAF Rule 230.2. Many athletes conduct specific race walk drills in training throughout the year to develop technique that is both legal and efficient. These drills typically include exercises that focus on the improvement of knee extension during stance, reduction of visible loss of contact, prevention of injury, increase in muscular power, and lessening of inefficient or uneconomical movements (such as excessive upper body motion). Drills that encourage correct technique throughout the body, such as through the development of shoulder and arm muscle strength, are particularly recommended[1].

Race walking is a learned skill that takes time to develop, and most of this learning occurs when athletes are youths and juniors.

Most current coaching advice with regard to drills adopted is based on theoretical points of view that need to be supported (or otherwise) by biomechanical measurements on trained race walkers. Training the correct movements and the muscles involved is clearly important for coaches, especially those of junior athletes[2], and hence a study of muscle activity using electromyography (EMG) will be very useful in identifying more specifically the role certain drills play in developing young race walkers' techniques. Research that does document these muscle characteristics in both men and women race walkers might therefore be useful in providing a strong rationale for strength training and a basis for the choice of exercises adopted. The aim of this study was to measure the effectiveness of several drills used by race walkers to ascertain their value in developing the correct muscle activity for this unique form of competitive gait.

Methods

Ten young race walkers gave informed consent and the study was approved by the Faculty Research Ethics Committee. Four of the athletes were male (age: 18.9 years (± 1.9), height: 1.76m (± .05), mass: 61.1kg (± 1.4)) and six were female (age: 19.8 years (± 3.5), height: 1.68m (± .07), mass: 55.2kg (± 7.4)). The sample included an IAAF world U20 10,000m champion. For the purposes of this study, men's and women's results have been grouped together. All participants were free from injury and tested during the competitive part of the season.

First, each athlete race walked along a 45m indoor track at a speed equivalent to their season's best time to allow for data to be collected on 'normal', competition-paced race walking. The athletes then completed a series of drills that are frequently used in training to develop movements relevant in race walking[3].

The drills undertaken during testing were:

- Knee Lift – the athlete race walks as normal but lifts the knees during late swing and touches them with the opposite, outstretched arm (Figure 1). Coaching aim: mobilise hip through greater flexion, and reinforce knee extension at heel strike.

Figure 1: Knee Lift drill

- Outstretched Arms – the athlete race walks as normal but holds the arms out to the sides (shoulder abduction of 90°) (Figure 2). Coaching aim: mobilise hips through greater extension, optimise posture, and guard against hip twist through effective hip rotation (manifested in an effective toe-off).

Figure 2: Outstretched Arms drill

- Windmill Arms – the athlete race walks as normal but circumducts the shoulders so that the arms rotate in opposite directions (Figure 3). Coaching aim: mobilise shoulder girdle and coordinate the upper and lower limbs.

Figure 3: Windmill Arms drill

Figure 4: Cradle Arms drill

- Cradle Arms – the athlete race walks as normal, interlocks the fingers and swings the arms from side to side as the thighs medially rotate during hip flexion (Figure 4). Coaching aim: mobilise shoulder and pelvic girdles and coordinate movement around central longitudinal axis.

- Arm Pull – the athlete race walks as normal but fully extends the elbows during the swing of the opposite leg so that the arm reaches far out in front of the body (Figure 5). Coaching aim: develop effective "pull" movement through hips from heel strike to create an "active" step, minimising braking forces.

- Foot Roll – the athlete takes very short steps emphasising landing on the heel and rolling over the foot (Figure 6). Coaching aim: mobilise lower limb and foot musculature through dorsiflexion rolling into plantarflexion, and facilitate the "pull" movement initiated in the "arm pull" drill (above)

Figure 5: Arm Pull drill

Figure 6: Foot Roll drill

Timing gates were placed 4m apart around two force plates (Kistler, Winterthur) that recorded both left and right foot contact phases and flight time. The force plates (1000Hz) were placed in a customised housing in the centre of the track and covered with a synthetic athletic surface so that the force plate area was flush with the runway to preserve ecological validity. A Fastec high-speed camera (100Hz) was positioned to the side of the runway (approximately 12m away) to provide videos for qualitative analysis. One of the athletes gave permission for screenshots of their videos to be used for Figures 1-6.

Surface EMG signals were recorded from eight lower limb muscles of the right leg: gluteus maximus, gluteus medius, biceps femoris, rectus femoris, vastus lateralis, gastrocnemius (lateral head), soleus and tibialis anterior. These muscles were chosen because of their important roles in competitive race walking.

Skin preparation involved cleansing of the skin with alcohol swabs[4], and shaving to remove any hair. After identifying the appropriate attachment sites by palpating the active muscle, each electrode was placed over the muscle belly, aligned parallel to the underlying muscle fibre direction[5].

A telemetry unit (DelSys, Inc., Boston) was used to collect the data at 1000Hz. EMG data collection lasted five seconds. The EMG hardware, force plate hardware and the high-speed camera were synchronised using a Kistler connection box; the start and end times of the contact phase were used to identify key events on the EMG traces (i.e., heel strike and toe-off). The raw EMG signals were processed using average rectified EMG (AREMG), with a time window of 50ms and an overlap of 25ms.

Muscular activity was quantified in two ways: first, the peak EMG during each drill was expressed as a percentage of the peak EMG found during competition-paced (normal) race walking; and second, the total EMG activity during each drill (one stride) was expressed as a percentage of the total EMG found during one stride of competition-paced (normal) race walking.

Results and Discussion

The purpose of this study was to measure the effectiveness of several drills used by race walkers with regard to their value in developing correct muscle activity. The results for muscle activity per drill are shown in Table 1 (peak EMG activity) and Table 2 (total EMG activity).

The gluteus maximus is a hip extensor that performs most of its work from late swing to early stance[6] and most drills (all except the Cradle Arms and Foot Roll) increased its activity. By contrast, the biarticular biceps femoris had less peak EMG activity in all six drills and less total EMG activity in half the drills. Both of these muscles are important in faster race walking because of their role in rapid extension of the hip during stance[7]. Furthermore, as the hamstrings are frequently injured in race walking because of their role in decelerating knee extension during swing[8], it is important that they are stressed appropriately and competition-paced walking in training might therefore be more relevant for developing this than using these drills. The gluteus medius is important in race walking because of its role in stabilising the pelvis when the opposite leg is swinging forwards. Like the biceps femoris, it was unde-

Table 1: Peak EMG activity in each muscle per drill as a percentage of competition-pace race walking

	Knees	Outstretched	Windmill	Cradle	Long Arms	Foot Roll
Gluteus maximus	131 (± 35)	169 (± 47)	138 (± 36)	99 (± 27)	144 (± 39)	51 (± 15)
Gluteus medius	72 (± 19)	84 (± 24)	124 (± 34)	91 (± 25)	86 (± 26)	62 (± 15)
Biceps femoris	97 (± 27)	85 (± 24)	85 (± 25)	90 (± 26)	85 (± 26)	47 (± 12)
Rectus femoris	128 (± 33)	125 (± 33)	136 (± 34)	126 (± 32)	125 (± 34)	86 (± 21)
Vastus lateralis	124 (± 35)	161 (± 47)	175 (± 48)	124 (± 37)	187 (± 52)	181 (± 47)
Gastrocnemius	95 (± 25)	97 (± 27)	116 (± 30)	92 (± 25)	108 (± 30)	92 (± 23)
Soleus	105 (± 29)	113 (± 33)	114 (± 32)	98 (± 27)	93 (± 25)	72 (± 19)
Tibialis anterior	96 (± 26)	97 (± 27)	90 (± 25)	92 (± 25)	89 (± 22)	83 (± 26)

Table 2: Total EMG activity in each muscle per drill as a percentage of competition-pace race walking

	Knees	Outstretched	Windmill	Cradle	Long Arms	Foot Roll
Gluteus maximus	110 (± 40)	112 (± 64)	112 (± 59)	91 (± 36)	126 (± 47)	51 (± 40)
Gluteus medius	75 (± 25)	90 (± 31)	123 (± 61)	94 (± 47)	92 (± 46)	92 (± 54)
Biceps femoris	117 (± 33)	92 (± 38)	98 (± 43)	105 (± 39)	107 (± 36)	63 (± 23)
Rectus femoris	123 (± 70)	137 (± 68)	138 (± 70)	132 (± 58)	133 (± 73)	118 (± 86)
Vastus lateralis	107 (± 50)	135 (± 40)	148 (± 76)	124 (± 83)	155 (± 84)	189 (± 137)
Gastrocnemius	89 (± 25)	95 (± 22)	111 (± 51)	93 (±39)	110 (± 60)	130 (± 56)
Soleus	103 (± 18)	109 (± 18)	118 (± 36)	112 (± 23)	101 (± 17)	97 (± 26)
Tibialis anterior	101 (± 34)	99 (± 11)	101 (± 23)	96 (± 31)	101 (± 23)	95 (± 44)

rused during all drills except the Windmill Arms drill; this drill increases the movement of the upper body, requiring extra stabilisation of the pelvis, and so might be useful in developing the strength of this important muscle.

The requirement for race walkers to straighten their knee from first contact with the ground until the vertical upright position (IAAF Rule 230.2) means that the knee extensor muscles are particularly important to train well. The two knee extensors analysed in this study, the rectus femoris and the vastus lateralis, form part of the quadriceps femoris group. The biarticular rectus femoris has been found to be less important with regard to knee straightening compared with its role in hip flexion in early swing[6]. The uniarticular vastus lateralis, by contrast, is active before and after heel strike and not only functions to straighten the knee but also to stabilise it[6]. Apart from peak rectus femoris EMG activity during the Foot Roll drill, all drills increased activity in the two knee extensors and showed their value in developing these key muscles. They might be particularly useful for those athletes who struggle with the knee straightening aspect of Rule 230.2.

In the lower leg, the gastrocnemius and soleus muscles work together to plantarflex the ankle and push the body forwards during late stance[6]. They are important energy generators in race walking and also aid performance by absorbing energy during midstance[9]. In general, there was little change in muscle activity during the chosen drills, although the Windmill Arms drill did show consistent increases in activity; furthermore, the Foot Roll drill did increase total gastrocnemius activity and so could be of value in developing this muscle. A major antagonist muscle of soleus and gastrocnemius is the tibialis anterior, which is often injured in race walking because of its role in preventing the foot from contacting the ground during swing[6]. With most drills there was little difference from the activity found during normal race walking (and only 83% of peak activity during the foot roll drill) and thus, like with the hamstrings, competition-paced race walking is important to practise to develop the strength and endurance of this important shin muscle.

When adopting drills in training, it is important that the benefits they bring to the athlete are not detrimental in some other way, for

Table 3: Mean speeds, contact times and flight times for normal competitive-pace race walking and for each type of race walking drill. Data for the foot roll drill are not presented

	Speed (km/h)	Contact time (sec)	Flight time (sec)	Step time (sec)
Normal	12.97 (± 1.10)	.281 (± .024)	.038 (± .015)	.320 (± .026)
High Knees	11.06 (± 1.44)	.291 (± .037)	.045 (± .029)	.336 (± .032)
Outstretched Arms	12.32 (± 1.09)	.288 (± .033)	.029 (± .023)	.317 (± .028)
Windmill Arms	11.65 (± 1.43)	.307 (± .027)	.027 (± .028)	.334 (± .021)
Cradle Arms	11.33 (± 1.79)	.314 (± .049)	.031 (± .022)	.345 (± .028)
Long Arms	13.42 (± 1.64)	.289 (± .030)	.050 (± .024)	.339 (± .027)

example by stressing the athlete's body in a manner that could cause injury. Furthermore, with regard to the technical demands of race walking, it is important that any drills used do not lead to the development of non-legal race walking technique. The results for speed, contact time, flight time and step time are shown in Table 3 (see next page). In terms of the visible loss of contact aspect of Rule 230.2, the race walkers in this study had mean flight times of 0.038 seconds at a mean race walking speed of 12.97km/h. Because of the nature of the movements emphasised, the knee drill and the long arms drill both increased flight time (even though step times were not greater than in the Windmill Arms and Cradle Arms drills), and thus the Knee Lift drill and Long Arms drill should be monitored in case athletes start to lose contact in competition as a result of using them. By contrast, the Outstretched Arms drill had a similar step time to competition-paced race walking but had a lower flight time component. Coaches should note which drills are more likely to lead to increased flight time, and if possible to monitor the speeds at which the athlete is carrying out the drill. Those undertaken at speeds greater than race pace (e.g., the Long Arms drill in this study) should be used with care as these speeds might be obtained through non-legal technique.

When considering which drills to use in training, coaches have to prioritise those that will lead to meaningful changes in performance or injury prevention. The drills in this study had varying degrees of value with regard to muscle activation, notwithstanding that some might be chosen more for potential benefits in motor skill development. There was no drill that activated all of the muscles analysed more than competition-paced race walking (which should always feature as part of any serious race walker's schedule), and this was particularly the case for the biceps femoris and tibialis anterior. The gluteus medius was also not served well by this selection of drills, and others might need to be considered in training (and tested in future research). By contrast, this set of six drills was very useful in activating the gluteus maximus, rectus femoris and vastus lateralis and should be considered as part of a routine to develop these key muscles.

Coaches seek not just to develop the endurance abilities of their athletes[10], but also the muscular qualities of economical and correct technique[11,12]. To date, training programmes have not been based on objective analyses of muscle activity during elite-standard race walking (e.g., there is no appreciation of the specific roles of muscles during each gait cycle or what types of muscle action occur during different phases) and as a result there is no guidance as to which exercises are most appropriate and which might even be useless or counterproductive. Historically, the main logic that has been adopted when coaches have prescribed strength development activities is whether or not the muscle acts concentrically during a particular exercise and whether that muscle also appears to be active during race walking (based on visual observation or anatomical knowledge). Current coaching advice on commonly used race walking drills is based more on coaches' experiences than on any objective evidence, and hence there is a need for further studies of muscle activity in race walkers. This will not only aid junior athletes for whom the current coaching advice is predominantly based around coaches' perceptions of the 'ideal' technique[13,14] but also experienced, senior walkers. Although there can be value in coaching based on previous experience (e.g., trying different approaches to see which works best), providing race walk coaches with scientific measurements and interpretation such as in the case of the drills analysed will enable them to use evidence-based practice, and lead to a systematic approach to the training of athletes[15].

Conclusion

Coaches and athletes use different drills for different needs and each of the six drills chosen had its own advantages with regard to muscle activation. Although the results here show the benefits of each drill in these terms, coaches need to consider their athletes' individual strengths and weaknesses (there were of course variations in how much activation occurred within each athlete tested).

Furthermore, the set of drills tested was not intended to be exhaustive and many others are used but should also be tested for their effectiveness. Training young athletes like those in this study to obtain legal and efficient technique often requires the use of such drills and indeed their value might be limited with more experienced athletes whose style has been developed and refined over many years. Future research on drills used in athletics (and not just in race walking) should look at muscle activation, and could also take a longitudinal approach with regard to their training effects.

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