Human Movement Science 36 (2014) 167–176

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

The effect of ankle muscle strength and flexibility on dolphin kick performance in competitive swimmers ☆

Tine M. Willems [a,*], Justien A.M. Cornelis [b], Lien E.P. De Deurwaerder [b], Filip Roelandt [c], Sophie De Mits [b]

[a] Ghent University, Department of Physiotherapy and Orthopedics, Ghent University Hospital, De Pintelaan 185, 13K12, 9000 Ghent, Belgium
[b] Ghent University, Department of Rehabilitation Sciences and Physiotherapy, Ghent University Hospital, De Pintelaan 185, 3B3, 9000 Ghent, Belgium
[c] Ghent University, Department of Movement and Sports Sciences, Watersportlaan 2, 9000 Ghent, Belgium

ARTICLE INFO

Article history:
Available online 28 June 2014

PsycINFO classification:
3720

Keywords:
Sports
Human swimming
Ankle joint
Stroke optimization
Dolphin kick

ABSTRACT

The velocity of a swimmer is determined by biomechanical and bioenergetics factors. However, little is known about the effect of ankle flexibility on dolphin kick performance. Next to this, scientific evidence is lacking concerning the influence of ankle muscle strength. Therefore, the aim of this study was to investigate the effect of ankle flexibility and muscle strength on dolphin kick performance in competitive swimmers.

Ankle range of motion (ROM) and ankle muscle strength were measured in 26 healthy competitive swimmers. The effect of both was assessed on the swimmer's velocity and lower extremity joint angles during three maximal dolphin kick trials. Additionally, the effect of a flexibility restriction by a tape on the dolphin kick performance was assessed.

Correlations were calculated between the flexibility, muscle strength and dolphin kick performance and differences were investigated between the unrestricted and restricted condition. Muscle strength of dorsal flexors and internal rotators were positively significantly correlated with the velocity. Active and passive plantar flexion ROM and internal rotation ROM were not significantly correlated. A plantar flexion–internal rotation

☆ No funding was received for this study.
* Corresponding author. Tel.: +32 499 75 79 08.
E-mail addresses: tine.willems@ugent.be (T.M. Willems), justien.cornelis@gmail.com (J.A.M. Cornelis), lien_de_deurwaerder@hotmail.com (L.E.P. De Deurwaerder), filip.roelandt@ugent.be (F. Roelandt), sophie.demits@ugent.be (S. De Mits).

http://dx.doi.org/10.1016/j.humov.2014.05.004

restriction during the dolphin kick showed a significant decrease in velocity. This restriction was associated with a changed movement pattern in the knee towards more flexion.

The results suggest that dolphin kick velocity might be enhanced by ankle muscle strength exercises and that subjects with a restricted ankle flexibility might profit from a flexibility program.

1. Introduction

The dolphin kick technique is mainly used in butterfly swimming, but likewise during the start and turn in crawl, breaststroke and backstroke swimming. It is an important component of the swimming race to minimize loss of velocity up until the initiation of the stroke and to improve the overall swimming performance (Lyttle, Blanksby, Elliott, & Lloyd, 2000). Performance in competitive swimming is determined by the time employed to complete the race distance. During the race, an underwater phase of 15 meters is allowed after the start and after every turn. During this underwater phase the resistance is diminished, therefore, kicking efficiently in this phase is extremely important. The dolphin kick can be performed in different positions such as prone, dorsal and lateral; the former being used most frequently. This prone dolphin kick consists of two phases: the upward kick, with feet and legs moving towards the surface of the water (also called the flexion kick or upbeat), and the downward kick, with feet and legs moving towards the bottom of the swimming pool (also called the extension kick or downkick) (Alves, Lopes, Veloso, & Martins-Silva, 2006). During the downkick, an extension of the knee is combined with a plantar flexion of the ankle, which is a smoother wave-like motion compared to the upward kick. Hereby, acceleration occurs as a reaction on water that is deflected to the back by the feet, causing propulsion (Colman, Persyn, & Ungerechts, 1999). It has been demonstrated that most of the thrust is produced by the feet and that the thrust produced during the downkick is much larger than during the upward kick (Cohen, Cleary, & Mason, 2012; von Loebbecke, Mittal, Mark, & Hahn, 2009).

Despite the frequent usage of this technique, the factors determining the effectiveness of the dolphin kick are rather unclear. The difference in performance level has a lot to do with skills (Costill, 1992), but physical abilities might have an influence as well. However, a recent review showed that the effects of most of the previous investigated parameters need further investigation (Connaboy, Coleman, & Sanders, 2009).

Many swim coaches believe that the flexibility of the ankles, especially towards plantar flexion and internal rotation, influences the efficiency of the dolphin kick during the downkick (Maglischo, 1993). A recent simulation study in a swimmer model showed that increased ankle flexibility did have an effect, primarily during and after the downkick (Cohen et al., 2012). Moreover, Sugimoto, Nakashima, Ichikawa, Miwa, and Takeda (2008) also found a 5° increased plantar flexion angle to have a significant effect on the thrust during the dolphin kick using a simulation analysis. Furthermore, two studies in breaststroke swimming documented that ankle inversion range of motion (ROM) was highly correlated (Kippenhan, 2002) and that the combination of knee external rotation and ankle supination flexibility explained 24.4% of the 100 m breaststroke results (Jagomagi & Jurimae, 2005). In addition, the strength of the ankle muscles might influence the velocity during the kick. However, scientific evidence to confirm this hypothesis is lacking.

Since previous research examining the effect of ankle flexibility on the dolphin kick performance was dominated by simulation studies, we preferred to investigate the effect in vivo. Therefore, a study was set-up to investigate the effect of ankle flexibility and muscle strength on the dolphin kick performance in competitive swimmers. Since propulsion is mainly produced during the downkick, where feet are moving towards plantar flexion and internal rotation, we focused on this phase. Since it was not clear if the active or the passive flexibility would have the greatest impact on the performance, both were measured. Additionally, the effect of a flexibility restriction through a tape was studied.