FORCE OUTPUT AND HIP MOVEMENT WHILE FLUTTER KICKING WITH VARIATIONS OF KICKBOARD SUPPORT

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Nine experienced swimmers completed two trials of 30 s of all-out kicking while holding onto one of three types of kickboards or without a board. Kicking force was measured via a force platform and hip roll via kinematic video anaylsis. The findings of the current study indicate that not using a kickboard results in greater kicking force than any of the three kickboards, which did not differ. Hip roll did not differ across the conditions ($p>0.05$). Based on the results of the present study, when seeking to overload the legs during kicking training, use of a kickboard may not be indicated.

KEYWORDS: swimming, hip roll, kicking force

INTRODUCTION:

Training the legs via a device such as the kickboard has become a vital part of most swim practices. The kickboard allows the legs to work without using the arms and thus may provide for overload training to strengthen the legs for the normal swimming stroke (Counsilman, 1968). Kickboards are usually made out of a type of buoyant material to keep the upper body from sinking. The legs also provide a small amount of propulsion, but the main benefit of the kick was that it serves as a stabilizer and neutralizer for the body (Alley, 1956; Bednarik et al., 1986; Hollander et al, 1988). A stable and neutral position of the hips has also been suggested to allow the kick to control body roll creating better horizontal and lateral position, thus resulting in a more forceful arm stroke (Maglischo, 1992).
Body position may also be altered when using a kickboard by promoting a flat body position while kicking, which some coaches believe is detrimental to the swimmer's technique in the overall effect it has on body position. These coaches believe that the kick board should not be used because of the poor position of the upper body when using them (Laughlin, 1998). They also believe that the kickboards produce poor development of the legs because of the arch in the lower back (Laughlin, 1998). Clarys (1979) found that the amount of drag was twice as great when in a flat horizontal position than when the swimmer was allowed to roll. Others suggest that the hips must roll in order to provide a better arm stroke (Maglischo, 1992). Additionally by not using the legs, the hips will either not roll enough or over roll causing instability in the hips and a large amount of turbulence that would slow the swimmer down (Maglischo, 1992).
Recently kickboard designs have been modified to help establish better horizontal and lateral alignment (Harris, 1998). One company has made claims that newer boards are smaller and cut at the bottom to allow more movement of the hips (Kiefer, 2000). This may keep the body in better alignment than the traditional tombstone shaped boards (Harris, 1998). However, these new designs have not been researched to confirm the purported benefits of the design. Therefore, the purpose of the current study was to examine the force production and hip roll while kicking with different kickboard designs or kicking without a board.

METHODS:

Subjects were nine experienced club swimmers (Mean ± SD; Age = 18.6±6.2 years; Years swimming = 5.2 ± 4.2 years). An informed consent form, approved by the university ethics committee, was reviewed and signed by each subject and guardian if the subject was under the age of 18. Each subject was asked to attend two separate sessions; the first session was used to provide familiarization with the experimental design and kickboards, the second session was the testing day.
For testing each subject kicked as hard as possible for 30 seconds with each kickboard three times. Order of kickboard was randomly assigned and a rest period of 3 to 5 minutes took

place between each trial. The four different conditions used were: kicking with three different styles of kickboards and without a kickboard. A 92 cm oak dowel with a 2.54 cm diameter with epoxy glue to the center of each kickboard to ensure that the dowel didn't effect floatation or alter the hand holds. For the non-kickboard condition subjects held onto a wooden dowel. Eyebolts (.635 cm) were drilled 1.3 cm from each end of the dowel and a 12.0 meter cable was fed through each eyebolt to form a "V" around the kickboard and swimmer. The cable was then attached to a single 2.75 m cable that was looped through a pulley system and fed into an eyebolt screwed into a force platform. To keep the apparatus from sinking, a flotation tube (2.75 meter long, 7.6 cm diameter) was placed on each side of the 12.0 meter cable and one tube on the cable that leading to the pulley system (Figure 1).

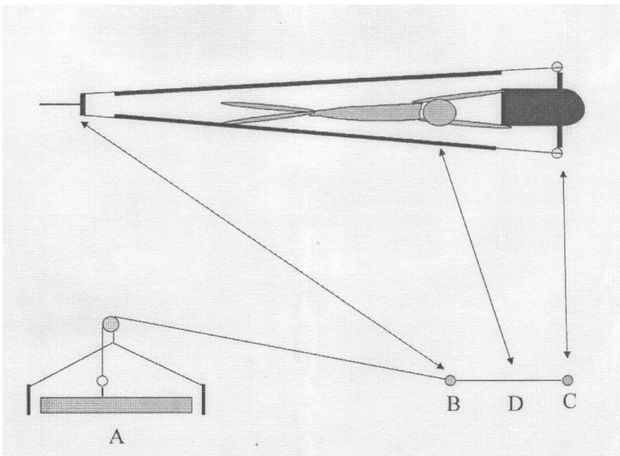

Figure 1. Apparatus connecting swimmer to force platform: (A) shows the force platform and pulley apparatus; (B) depicts the junction between the two cables; (C) illustrates the kickboard with oak dowel attached and (D) shows the cables with the float tubes attached.

An AMTI OR6-5-2000 (Advanced Medical Technology, Inc., Watertown, MA) force platform was used to determine the amount of horizontal force that the subject could create by kicking and was zeroed prior to each use. Horizontal force was defined as the mean kicking force during the 30 second trial. The force platform was attached to an AMTI MSA-6 amplifier and data was collected at 1000Hz on an IBM compatible computer via AMTI Biosoft 1.0 software. Gannon and Jensen (1998) have reported this system to be reliable to measure horizontal pulling forces (ICC R = 0.98). All data was saved for later statistical analyses.

Video analysis of hip roll during kicking was performed for eight subjects using the three kickboards, as well as with no kickboard. A retro-reflective marker was placed on each of two 0.9-meter dowels extending from a belt around the anterior superior iliac spine to above water level. This allowed rotation of the hips, relative to horizontal, to be determined via video analysis. A Canon Optura 20 video camera was used to film the kicking at 60 Hz. The video of the hips was analyzed using PEAK Motus 5.1 (Englewood, CO) and the data was saved for statistical analysis. One complete kick cycle was digitized starting with the right leg at the lowest point to the surface of the water, moving through the up beat and down beat back to the starting position. Hip roll was defined as the maximum angular distance in degrees covered in one kick cycle.

Statistical analyses were performed using SPSS 13.0 for Windows. Reliability of the kicking force and hip roll were assessed across the three trials using Intra Class Correlation (ICC). A One-way repeated measures ANOVA was used to compare hip roll and kicking force across the four kickboard conditions. An alpha level of 0.05 was selected with Greenhouse-Geyser correction if sphericity was violated. Effect sizes using partial eta^2 (η_p^2) were also obtained for each dependent variable using the formula: $\eta_p^2 = SS_{effect} / (SS_{effect} - SS_{error})$, where SS_{effect} = effect variance and SS_{error} = error variance. Interpretation of effect size was done using a scale for effect size classification based on F-values for effect size and were converted to η_p^2 using the formula: $F = (\eta_p^2 / (1 - \eta_p^2))^{0.5}$. Consequently, the scale for classification of η_p^2 was: 0.04 = trivial, 0.041 to 0.249 = small, 0.25 to 0.549 = medium, 0.55 to 0.799 = large, and .0.8

= very large (Comyns et al., 2007). If significant differences were noted, a Bonferroni's post-hoc test was performed.

RESULTS:

Reliability analysis indicated that measures of kicking force had high ICC (single measure R = .917 average measures R = .995) and no differences between trials (p = 0.174). For hip roll ICC was also high single measure R = .880 average measures R = .965) and no differences between trials (p = 0.701). Due to the high ICC and lack of difference between trials, the average of the three trials was used for all further comparisons.

Repeated Measures ANOVA indicated there was a significant difference for kicking force between the types of kickboards used while kicking ($p = 0.036$; $\eta_p^2 = 0.443$). Post hoc analysis indicated that not using a kickboard resulted in greater force production than any of the kickboards, while there was no difference between the kickboards (see Table 1).

Hip roll data showed that no significant difference ($p = 0.948$; $\eta_p^2 = 0.017$) existed between the four conditions for the amount of rotation the hips created while kicking. Indeed, Table 1 shows there was less that 2º difference for the mean hip roll across all four conditions.

Table 1 - Mean (± SD) force (N) and hip roll (º) while kicking with various kickboards (n = 8).

Type of Kickboard	Kicking force (N)	Hip roll (º)
Kiefer	34.3 ± 10.6	106.0 ± 5.3
None	37.9 ± 11.7[a]	104.9 ± 7.7
Traditional	32.9 ± 9.8	105.4 ± 6.0
Zion	32.5 ± 12.2	104.6 ± 8.7

[a]Significantly greater than all other conditions (p>0.05).

DISCUSSION:

Previous research on the flutter kick has mostly centered on the question of whether the kick is actually a propulsive component to the full stroke. Most authors have agreed that the legs can create some propulsion but only for a limited time (Counsilman, 1968; Hay, 1993; Maglischo, 1992; Yanai, 2001). Because research has shown that the legs can act as a propulsive component, coaches have been using kickboards as a way to overload the legs and strengthen the effectiveness of the kick. The current study centered on the kickboard and the amount of force that can be created by the swimmer with different styles of kickboards. The results suggest that for kicking, the amount of force a swimmer can produce is dependent on a certain type of kickboard or even the lack of one.

Participants were asked after the experiment, which style of kickboard was most comfortable for them, with five preferring the traditional board, two the Zion and two the Kiefer. None of the participants thought that the condition of no kickboard was best even though several stated that kicking without a board was part of their training regimen. This might have been due to the unusual style with which the swimmers had to hold on to the oak dowel. For the current experiment, when kicking without a board, subjects were required to hold their heads out of the water to ensure that the position of the body in each of the conditions was as similar as possible. Usually kicking without a board is done on the side to simulate kicking with the whole stroke (Laughlin, 1998). Although some of the styles of the boards have been made to bring the shoulders lower in the water and the board itself less buoyant, qualitative observations suggested that the lighter the board, the more the body dropped below the surface of the water. According to Yanai (2001) a swimmer who tends to sink in the static position has to increase the kicking effort necessary to elevate the legs and maintain horizontal alignment.

The hip roll data taken from four different conditions ranged from 90 to 114.5 degrees. It should be noted that the analysis of the hip roll was done for a full cycle (both the right and left legs) of up and down movements. The amount of hip roll showed no statistically significant differences, this suggests that kicking with or without a board has no bearing on hip rotation. It has been suggested that the body roll for the whole stroke should be 40º or more for each side (total of 80º) when swimming (Maglischo, 1992). The current study showed that using only the legs results in the hips moving more than 40º, which suggests that kicking alone with or without a kickboard simulates where the legs would be during whole stroke swimming. Hence the statements made by Laughlin (1998) that kicking with a board does not work the legs muscle appropriately due to lack of hip roll, are not supported by the current data.

It should be noted that the difference in force production during the non-board condition ranged from only 3.6 to 5.4 N, however, this was equal to 9.5 to 14.2% of the non-board force production. Furthermore although the absolute values were not very large, the calculated effect size of 0.443 would indicate a medium effect across kicking forces. Another point to consider is that because the swimmers were attached to the force platform, the kicking of the current study simulated a tethered or "quasi-static" position. There may be differences in force production during dynamic swimming compared to the tethered condition. One possibility might be variations in lift and drag that take place during movement.

CONCLUSION:

Several points have been noted from the results of the current experiment. One is that force output can be significantly different depending on the kickboard; the second point is that the hips can rotate even when kicking with a board although no significant difference exists between the kickboard styles. Findings may benefit coaches when trying to determine what type of kickboard to use during training or even to make the call to not use a kickboard.

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