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Effects of weighted arm sleeve loading on golf shot parameters

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ABSTRACT

Golfing performance is dependent on the distance and trajectory of an athlete's shot. The aim of this study was to determine how unilateral and bilateral loading strategies between 100-400 g placed on the forearms affected golf shot parameters related to carry distance and carry side distance. Nine experienced right-handed golfers, eight males (age: 24.5 ± 11.1 yrs; body mass: 84.8 ± 13.0 kg) and one female (age: 16.0 yrs; body mass: 73.6 kg), with an average handicap of 3.8 ± 2.6 performed golf shots with and without wearable resistance (WR) on their forearms. Unilateral loading on the lead arm resulted in increased carry distances from 1.68-1.78%, with 200 g loading significantly enhancing performance ($p = 0.04$; ES = 0.72). Unilateral loading of both 200 g and 400 g on the lead arm resulted in a large and very large change to carry side distance leading to a leftward ball trajectory ($p = 0.02$ and 0.01, respectively; ES = -2.07 and -4.43, respectively). No clear trends in individual performance were observed, apart from WR loading tending to cause a leftward carry side distance change back towards the target line in most of the subjects. These findings indicate that arm-loaded WR may be used to influence swing mechanics, which may assist ball carry trajectory in the desired direction, depending on a golfer's individual abilities and needs.

1. Introduction

Golf has become one of the most popular sports which is practiced by 10-20% of adult populations in many countries (Thériault & Lachance, 1998), equating to roughly 55-80 million participants worldwide (Evans & Tuttle, 2015). Golf performance is determined by a person's ability to hit the ball into the hole in as few shots as possible. In order to achieve this outcome, golfers must be able to hit the ball accurately and at high velocities (Hume et al., 2005). Given the importance of both approach shot distance and accuracy (Broadie, 2012), it is no surprise that a number of acute strategies such as stretching protocols (Fradkin et al., 2004), post-activation potentiation schemes (Read et al., 2013), and wearable resistance (WR) loading (Macadam et al., 2019) have been explored to enhance golf shot performance. Interestingly, static stretching appears to diminish shot distance and accuracy (Gergley, 2009). Therefore, dynamic strategies are recommended to acutely enhance golf performance (Moran et al., 2009). One such strategy is the use of WR, which enables golfers to perform dynamic actions specific to the swing.

A number of research teams have found that limb-loaded WR can be used to overload sport-specific movements, such as running, sprinting, and jumping with minimal technical disruptions (Field et al., 2019; Macadam et al., 2017; Uthoff et al., 2020) and can be used as a training stimulus during normal practice sessions to enhance athletic capabilities (Bustos et al., 2020). Based on the equation for rotational inertia (i.e., inertia = mass x perpendicular distance from the axis of rotation^2), it has been postulated that distal loading of the limbs (i.e., away from center of mass) provides specific rotational overload, otherwise not accomplished with traditional, linear, resistance training (Macadam et al., 2017; Macadam et al., 2018). Therefore, the addition of WR applied to the distal aspect of the arm of a golfer might contribute to increased rotational inertia, and therefore, affect shot parameters such as distance and trajectory.

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Using a cross-over design, researchers have loaded the trail side trunk and hip of well-trained golfers with loads of 1.6 kg (~2.8% body mass [BM]) attached posteriorly, to find 3.5% increases in club head speed and 7.2% increases in shot distance, relative to an unloaded condition (Macadam et al., 2019). While the effects of WR on carry distance are promising, it is important to note that the effects of WR on golf shot accuracy has yet to be investigated. Furthermore, it is currently unknown how load and placement strategies on a golfer's arms affect shot distance and accuracy. Therefore, we examined how unilateral and bilateral loading between 100-400 g placed on the forearms affected golf shot parameters related to carry distance (i.e., the distance a ball travels in the air) and accuracy. A secondary aim of this project was to determine if any potentiation, or unloading affect, was observed for carry distance or accuracy once the WR was removed.

2. Methods

2.1. Study Design and Experimental Overview

A single session, acute randomised cross-sectional design was used to examine the effects of different arm loading patterns on drive shot parameters. Subjects warmed up as per their usual procedures. They then performed five unloaded swings of their own 7 iron club. Thereafter, five swings were performed under seven randomised loading conditions (4 loads and 3 positions). Finally, five unloaded swings were performed after the loading conditions.

2.2. Participants

Eight male golfers (age: 24.5 ± 11.1 yrs; body mass: 84.8 ± 13.0 kg) and one female golfer (age: 16.0 yrs; body mass: 73.6 kg) with an average handicap of 3.8 ± 2.6 agreed to participate in this study. All were healthy and injury free for the duration of the testing period. Individual athlete information can be found in Table 1. Due to COVID-19 restrictions, this was a convenience sample of skilled golfers available to us at the time. Subjects provided written informed consent prior to participating in this study. This research was approved by Auckland University of Technology's Ethics Committee (20/66) and adheres to the Declaration of Helsinki.

2.3. Apparatus

Foresight Sports (San Diego, CA, USA) GC Quad camera-based launch monitor was placed beside the ball and used to determine impact conditions of the ball and club in order to calculate carry distance (i.e., the distance the ball travels in the air down the field of play) and side carry distance (i.e., the perpendicular distance from the target line to the landing point of each shot) (Leach et al., 2017). The GC Quad launch monitor collects images of the golf ball during its initial flight at 3,000 Hz. It then performs calculations using proprietary Foresight GC Quad built-in software algorithm to estimate the dependent variables (i.e., carry distance and carry side distance) (McNally et al., 2019).

The WR equipment worn by the subjects during the loaded conditions were Lila™ Exogen™ compression sleeves (Sportboleh Sdh Bhd, Malaysia). This WR garment allowed for loads of 50 g to 400 g with Velcro backing, to be attached to fixed sleeves on each lower arm. This enabled loads to be distributed either unilaterally or bilaterally without the sleeves moving during the trials.

2.4. Procedures

Subjects performed a warm-up identical to what they would normally do before playing or practicing golf prior to the testing session. Thereafter, each subject performed a total of 45 swings. The first five shots were performed under an unloaded (natural) condition. The subjects then hit five balls from each of the seven loaded conditions in a randomised order to mitigate learning, order, fatigue, and or motivation effects. The subject then hit five balls unloaded following the loaded conditions.

Table 1: Individual athlete characteristics.

Subject #	Age	Handicap	Mass (kg)	Sex
1	40	3.2	83.0	male
2	27	7.6	99.3	male
3	42	3.3	85.3	male
4	17	1.2	75.7	male
5	15	0.5	66.2	male
6	15	6.2	79.4	male
7	16	5.5	73.5	female
8	16	5.9	93.0	male
9	24	0.8	106.6	male

Figure 1: Loading placement for forearm WR with bilateral 200g

Lower arm (forearm) sleeves were used on both arms of the golfer. Neutral loading of the lower arm was placed distal to the elbow (see Figure 1). The loading conditions included: bilateral 50 g per arm, bilateral 100 g per arm, bilateral 200 g per arm, unilateral 200 g trail arm, unilateral 200 g lead arm, unilateral 400 g trail arm, unilateral 400 g lead arm.

2.5. Statistical Analysis

Outlier analysis was conducted on all data and thereafter the averaged data was used for statistical analysis. The independent variables of interest in this study were the unloaded and loaded WR conditions. The dependent variables of interest included: carry distance and carry side distance (n.b., a positive number indicates the ball landed to the right of the target and a negative number indicates the ball landed to the left of the target). Means and standard deviations were used as measures of centrality and spread of data. Homogeneity of variance was assessed via the Levene's test. Normality was analysed using the Shapiro-Wilk test. The comparison of interest was how each load affected golf shot parameters compared to the unloaded condition, and not the effects between loading conditions. Therefore, paired t-tests were used to identify pairwise differences in the mean between loaded and unloaded conditions. Percentage change in the mean was determined to identify relative changes in the mean between baseline performance and the experimental conditions. Hedges' s g effect size was calculated on the mean change from baseline to determine the practical effects of WR loading conditions on carry distance and carry-side distance. 95% confidence limits were reported, and alpha was set at $p \leq 0.05$.

3. Results

3.1. Carry Distance

3.1.1. Group changes

Bilateral loading resulted in trivial to small effects with average percentage changes ranging from -0.19 to 1.78%. Unilateral loading of 200 g on the lead arm resulted in a significant increase (1.78%; $p < 0.05$) in carry distance with a moderate effect. Results from the paired t-tests found that unilateral loading on the trail arm did not have a clear effect on carry distance, with no observable differences between the 200 g and 400 g conditions; though, both conditions demonstrated a large effect on performance ($g \leq -0.84$) with both high and low 95% CI in the 200 g condition being negative. No potentiation effect was observed for mean carry distance. See Table 2 for full carry distance results.

3.1.2. Individual changes

The individual responses for carry distance to each loading condition, presented as a percentage change relative to baseline are detailed in Figure 2. The individual responses for carry distance ranged from -16.1 to 7.42%, with no clear or identifiable trends.

Table 2: Effects of forearm WR loading on mean carry distance, percentage change, effect size and significant difference from baseline performance. * = P < 0.05.

Condition	Mean ± SD	% change (95% CL)	ES (95% CL)	P value
Baseline	151.2 ± 14.8			
Bilateral 50 g	152.8 ± 16.7	1.78 (-0.79 to 4.34)	0.40 (-0.54 to 1.33)	0.35
Bilateral 100 g	152.6 ± 17.3	0.86 (-2.08 to 3.79)	0.34 (-0.59 to 1.27)	0.58
Bilateral 200 g	151.1 ± 17.4	-0.19 (-2.36 to 1.99)	-0.03 (-0.95 to 0.90)	0.95
Final	152.3 ± 19.1	0.51 (-2.59 to 3.61)	0.25 (-0.68 to 1.18)	0.66
Unilateral lead 200 g	154.1 ± 17.0	1.78 (0.24 to 3.33)	0.72 (-0.25 to 1.68)	0.04*
Unilateral lead 400 g	154.0 ± 18.9	1.68 (-1.11 to 4.47)	0.66 (-0.30 to 1.62)	0.22
Unilateral trail 200 g	146.5 ± 17.8	-3.19 (-7.11 to 0.74)	-1.16 (-2.19 to -0.14)	0.17
Unilateral trail 400 g	147.8 ± 17.6	-2.34 (-5.21 to 0.53)	-0.84 (-1.81 to 0.14)	0.18

3.2. Carry Side Distance

3.2.1. Group changes

Bilateral loading showed mixed results. Bilateral loading with 50 g resulted in a small leftward effect on carry side distance of -135.9%, though this did not reach significance (p = 0.235). Unilateral loading on the lead arm had a very large effect on carry side distance, resulting in all the golfer's carry side distances to significantly pull to the left approximately 10 m at 200 g (p = 0.019), and seven out of the nine participants pulled approximately 20 m to the left in the 400 g condition (p = 0.009). The pairwise analysis did not clearly identify changes from baseline for the 200 g and 400 g trail arm loaded conditions; however, unilateral loading with 200 g had a large effect and 400 g loading resulted in a very large effect on golfer's mean carry side distance pushing to the right, where all 95% CL were found to be positive. While the paired t-test did not clearly identify a change from baseline to the final unloaded condition, a large potentiation effect was observed on mean carry side distance, where both high and low 95% CI in the final condition were found to be negative. See Table 3 for full carry side distance results.

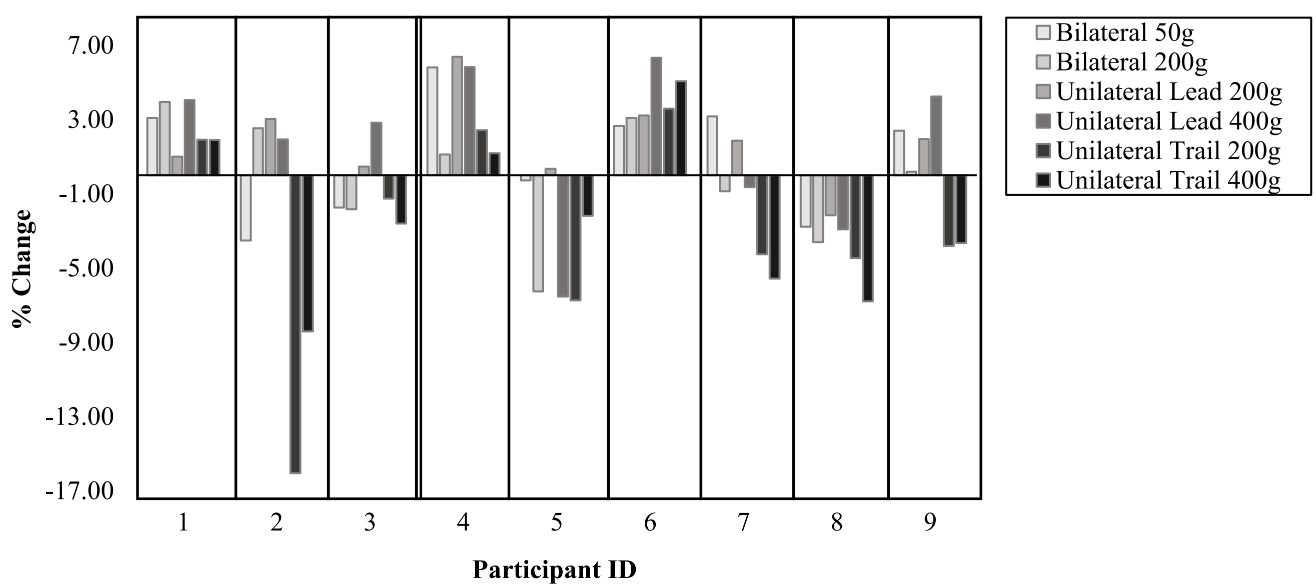

Figure 2: Individual percentage changes for golfers' carry distance for each loading condition compared to baseline.

Table 3: Effects of forearm WR loading on mean carry side distance, percentage change, effect size and significant difference from baseline performance. * = P < 0.05.

Condition	Mean ± SD	% change (95% CL)	ES (95%CL)	P value
Baseline	2.22 ± 11.1			
Bilateral 50g	1.33 ± 5.24	-135.9 (-236.0 to -35.8)	-0.37 (-1.37 to 0.63)	0.24
Bilateral 100g	2.51 ± 9.39	42.9 (-120.3 to 206.0)	0.11 (-0.84 to 1.06)	0.25
Bilateral 200g	-0.04 ± 8.80	-40.4 (-199.0 to 118.3)	-0.90 (-1.89 to 0.08)	0.49
Final	-2.51 ± 14.7	-61.9 (-212.9 to 89.1)	-1.45 (-2.53 to -0.38)	0.17
Unilateral lead 200g	-3.67 ± 11.7	-105.0 (-262.8 to 52.9)	-2.07 (-3.28 to -0.86)	0.02*
Unilateral lead 400g	-8.63 ± 8.74	-168.1 (-416.5 to 80.3)	-4.34 (-6.22 to -2.46)	0.01*
Unilateral trail 200g	7.76 ± 10.7	-15.0 (-123.6 to 93.5)	2.03 (0.83 to 3.23)	0.12
Unilateral trail 400g	9.23 ± 9.23	57.0 (-0.40 to 114.4)	2.64 (1.24 to 4.05)	0.14

3.2.2. Individual changes

The individual responses for carry side distance to each loading condition, presented as a percentage change relative to baseline can be observed in Figure 3. The individual responses for carry side distance ranged from -1029.4% to 520.6%. No clear trends can be observed from the data apart from arm loading tending to cause a negative carry distance change in most of the subjects.

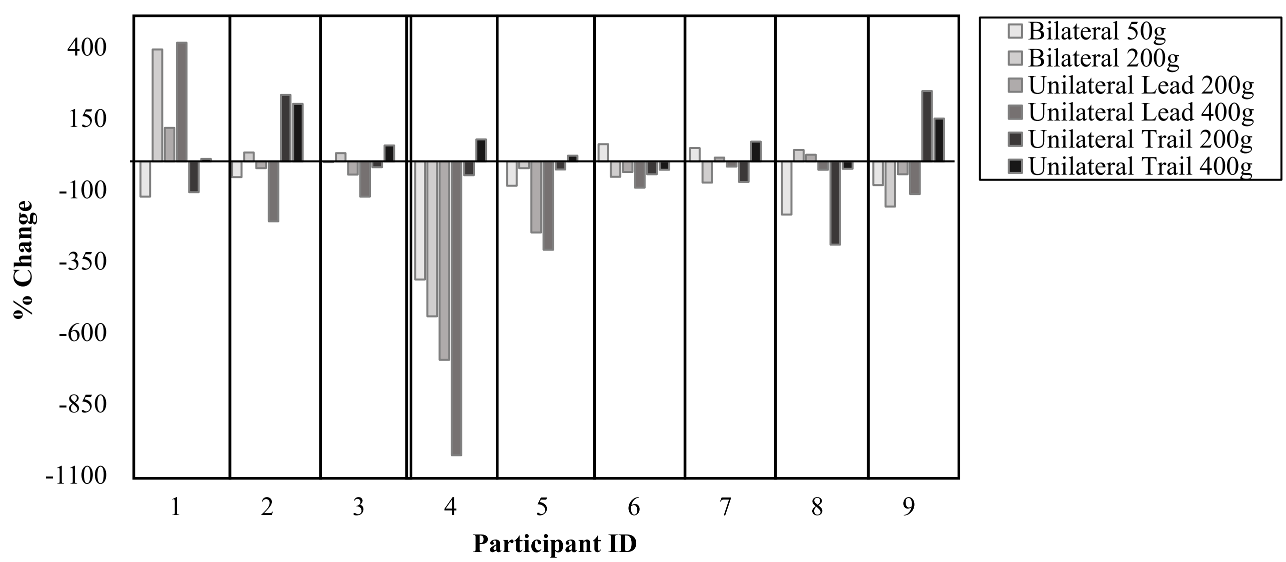

Figure 3: Individual percentage changes for golfers' carry side distance for each loading condition compared to baseline.

4. Discussion

Loading of the lead arm, particularly at 200g, may be a means to increase carry distance to a moderate degree; especially, in athletes with low handicaps. It appears that unilateral loading on the lead arm, especially at loads of 400 g, initiated club head rotation closure, resulting in a more leftward ball trajectory of approximately 20 m.

The practical applications of these findings are, if a golfer is known to have a rightward carry side distance (which generally results from an open club face at impact) then lead arm loading with up to 400g may be used to increase club face closure, resulting in a straighter, or more advantageous ball trajectory. However, if the goal is to initiate club-ball contact with a more open club face, then higher loads on the trail arm could be used to prompt changes relative to those seen with the lead arm. Please note however, the variability of the individual responses in carry distance and carry side distance to the various loading patterns. This is important as arm-loaded WR may therefore be used to correct swing mechanics, which may assist ball carry trajectory in a desired direction, depending on a golfer's individual abilities and tendencies.

Results should be interpreted with caution as this paper only tested a small population of skilled golfers. Future research would need to generalize these results to specific populations. Also, the lack of changes observed in the final unloaded condition in this study could be due to the different changes observed across different loading conditions. This study also only examined the acute effects of WR on outcome parameters. Further research should investigate whether training with a specific WR loading condition (unilateral loading of the lead arm) over time could produce more permanent changes in swing technique/mechanics when not wearing the WR in competition.

Conflict of Interest

Professor John Cronin holds the position of Head of Research at Lila Movement Technology, the manufacturer of the wearable resistance garment used in this study. However, Professor Cronin is an academic researcher first and was blinded from the data collection and analysis. His primary roles were in the conception of the study design and revision of the manuscript.

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