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ORIGINAL ARTICLE

External oblique activation is augmented with a water-filled resistance training implement compared to a static load

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ABSTRACT

This study investigated the effects of a water-filled resistance training device (WTD) compared to a static training load on core muscle activation in the rectus abdominis (RA) and external obliques (EO) during a rotational core exercise. Twelve college-aged male participants with moderate resistance training experience performed 4 sets of 12 repetitions on each side of the Russian twist exercise using both the WTD and a static-weight control in a randomized crossover design on two separate days. Surface electromyography (sEMG) was used to measure muscle activation in both conditions. Results indicated that the WTD condition elicited greater mean and peak muscle activation in both muscle groups compared to the control. EO activation was 85% higher in mean (*p* = .002, d = 0.95) and 77% greater in peak (*p* = .002, d = 1.59) values, while no significant difference in RA activation was identified between groups. These findings suggest that the WTD enhances activation of the external obliques relative to a static load, supporting its potential use in instability-based training for moderately trained males.

Keywords: Performance analysis, Core muscle, Instability, sEMG.

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INTRODUCTION

Core strength plays a pivotal role in human movement, providing stability in the context of both daily activities and athletic performance (Escamilla et al., 2010). Strengthening the core musculature, particularly the rectus abdominis (RA) and external obliques (EO), has been shown to improve spine stability while simultaneously reducing the risk of injury and other musculoskeletal disorders (Kim and Oh, 2015; Oliva-Lozano and Muyor, 2020). Traditionally, core training has relied on static resistance exercises involving fixed weights, such as dumbbells, barbells, and various resistance machines. However, recent research in regards to instability resistance training, specifically within the core musculature, suggests that introducing unstable conditions may elicit greater neuromuscular engagement and subsequent training adaptations (Batistia et al., 2024).

Instability resistance training primarily involves unstable surfaces or shifting loads designed to challenge an individual's ability to stabilize themselves while experiencing dynamic movement. This style of training has been shown to increase core activation relative to stable conditions, likely due to increased proprioceptive demands and muscle recruitment (Kim and Oh, 2015; Batista et al., 2024; Saeterbakken et al., 2022). Commonly utilized instability tools, such as yoga balls, Swiss balls, and foam rollers, require greater muscle coordination in order to control their movement. More recently, water-based instability implements have become more popular as an alternative instability training modality. Unlike traditional methods, water-based implements create shifting loads through the unpredictable movement of water, potentially leading to increased core activation by necessitating compensatory adjustments for stabilization (Glass et al., 2016).

Despite the growing interest in water-based resistance tools, research largely remains limited in regards to their effectiveness relative to static weights. Many prior studies have focused on unstable surfaces rather than unstable loads, such as the one produced by the shifting of the water (Saein et al., 2024; Behm et al., 2010). Furthermore, research has shown conflicting results, as although some studies have shown increased core muscle activation in exercises that have greater stability requirements (Oliva-Lozano and Muyor, 2020; Batista et al., 2024; Bao et al., 2025), others have not (Saeterbakken et al., 2022). In regard to the core musculature, some evidence suggests that unstable loads can enhance neuromuscular engagement (Batista et al., 2024). However, it remains to be determined if water-filled resistance training provides a unique stimulus beyond that of traditional weights. Previous studies using sEMG have shown increased core muscle activation when core exercises were performed with other instability modalities, such as Swiss and BOSU balls (Escamilla et al., 2010; Czaprowski et al., 2014). Furthermore, although prior studies have included a water-based implement, they have primarily focused on the activation of the core through secondary core exercises, such as bicep curls, squats, and the clean and jerk (Ditroilo et al., 2018; Glass et al., 2016; Calatayud et al., 2015). As such, no studies have directly compared core muscle activation between water-filled training tubes and a static weight using surface electromyography (sEMG) during core-focused exercises.

The primary aim of this study is to assess the impact of a water-filled training tube on core muscle activation in the rectus abdominis and external obliques relative to a static weight during the execution of a core-focused exercise. We hypothesize that the water-filled training tube will elicit greater core muscle activation, measured via sEMG, compared to that of the static weight.

METHODS

Participants

Twelve apparently-healthy male participants (n = 12) from Southern California volunteered for this study. Inclusion criteria included individuals aged 18-35 years old with moderate experience in resistance training, defined as engaging in structured, resistance-based training (e.g., weightlifting, bodyweight training, or similar exercises) at least 2 to 3 times per week for a minimum of 3 to 6 months. This was done to ensure participants possess the strength and familiarity necessary to effectively lift and stabilize the water-filled resistance training device (WTD). Exclusion criteria included the presence of recent upper-body or core-related injuries that may inhibit performance, any significant musculoskeletal, cardiovascular, or pulmonary disorders that may limit exercise ability, and the use of any drugs and/or supplements that enhance anabolic performance. A sample size of n = 10 was calculated based on α priori power analysis using sEMG data from an unpublished exploratory study of a similar study α = 0.05 and Β = 0.20, using five resistance-trained, collegiate-aged males. All exploratory participants provided written informed consent while ethical approval was obtained from UCLA (IRB: 11-003190). Off-site participants provided written informed consent and single IRB approval (sIRB: BRANY, NY, USA). Research practices were conducted in full accordance with the ethical standards established by the Declaration of Helsinki and the International Journal of Exercise Science (Navalta et al., 2019).

Study design

This study was a one-week, single-blind, randomized crossover research design. Each participant completed two sessions, no less than 48 hours apart: one in the intervention condition, using the WTD, and the other in the control condition, using a static weight of equivalent mass. The order of conditions was randomized using an online random number generator. During each session, participants performed Russian Twists, a seated rotational core exercise in which the torso is twisted from side to side while holding a weight. The exercise was performed for 4 sets of 12 repetitions per side under each condition.

Patients were instructed to follow the tempo of an online metronome with a cadence of 40 beats per minute, switching sides during the exercise every 1.5 seconds. Prior to their participation in the study, participants were asked to avoid any strenuous or additional resistance training for the duration of their participation in the study. A two-minute break was provided between sets. All sessions were monitored by researchers under the guidance of the lab director at the UC Fit Digital Health - Exercise Physiology Research Laboratory at UCLA.

Anthropometric measures

Body mass and height

Body mass and Height: Body mass was measured on a calibrated medical scale (accuracy ±0.1 kg), and height was determined using a precision stadiometer (Seca, Hanover, MD, United States; accuracy ±0.01 m). In a fasted state and after voiding their bladder, participants were instructed to remove unnecessary clothing and accessories prior to being weighed, as well as remove their shoes prior to taking height measurements.

Body composition

Body fat percentage was measured using a validated octipolar, multi-frequency, multi-segmental bioelectrical impedance analyser (BIA) (InBody Co., Seoul, Korea Republic) (Dolezal et al., 2013). To ensure accuracy, participants adhered to standard pre-measurement BIA guidelines recommended by the American Society of Exercise Physiologists (Heyward, 2001). Briefly, the test was performed after at least 3 hours of fasting and voiding, with participants instructed to remain hydrated and not exercise 2 hours before testing. After investigators explained the procedure, the participant stood upright with their feet on two metallic footpads while holding a handgrip with both hands. The instrument measured resistance and reactance using proprietary algorithms.

Protocol

Participants reported to the UCFIT Digital Health - Exercise Physiology Research Laboratory on two non-consecutive days (within no less than 48 hours apart) at the same time of day under controlled temperature conditions. Body mass was measured on a calibrated medical scale (accuracy ±0.1 kg), and height was determined using a precision stadiometer (Seca, Hanover, MD, United States; accuracy ±0.01 m). In a fasted state and after voiding their bladder, participants were instructed to remove unnecessary clothing and accessories prior to being weighed, as well as remove their shoes prior to taking height measurements.

Following body mass measurement, body fat percentage was assessed using a validated octipolar, multi-frequency, multi-segmental bioelectrical impedance analyser (BIA) (InBody Co., Seoul, Korea Republic) (Dolezal et al., 2013). To ensure accuracy, participants adhered to standard pre-measurement BIA guidelines recommended by the American Society of Exercise Physiologists (Heyward, 2001). Briefly, the test was performed after at least 3 hours of fasting and voiding, with participants instructed to remain hydrated and not exercise 2 hours before testing. After investigators explained the procedure, the participant stood upright with their feet on two metallic footpads while holding a handgrip with both hands. The instrument measured resistance and reactance using proprietary algorithms.

Participants were then fitted with two MR EMG sEMG sensor recording devices (MR EMG, Dunedin, New Zealand). In accordance with previously established sEMG practices, one MR EMG sensor was placed 4 cm to the right of the participant's navel to record the sEMG activity of their RA.16 The second MR EMG sensor was placed halfway between the anterior superior iliac spine (ASIS) and the most inferior point of the costal margin (Huebner et al., 2015). The sEMG sensors were placed on the right side muscles only, as prior research has demonstrated sEMG reading symmetry between the left and right core muscles (Escamilla et al., 2010; Escamilla et al., 2006; Ng et al., 1998). Prior to placement, the area was shaved and rubbed with an alcohol pad by the researcher to ensure proper connectivity for each sensor.

Before beginning the exercise, participants received standardized verbal instructions and a live demonstration of the Russian Twist exercise by a trained research assistant. To ensure proper form, participants were instructed to begin in a seated position with their legs extended in front of them and their heels lightly contacting the floor. Participants maintained a straight back while leaning slightly backward at an approximately 45° angle from vertical.

The WTD was held with both hands using an underhand grip on its horizontal handles, positioned at chest level. During the exercise, participants were instructed to rotate their torsos alternatively to the right and left while keeping their lower bodies stable and elbows tucked close to their torso. Rotation was paced using an online metronome set at 1.5-second intervals. At each beep of the metronome, participants rotated the WTD to the opposite side, completing one full repetition after returning the WTD to its original position.

Four sets, each consisting of 12 repetitions per side, were completed with a 90-second rest period in between each set. A trained research assistant was present throughout all sessions to monitor safety, provide real-time feedback strictly related to form, and ensure adherence to the standardized protocol.

Resistance tube specifications

The experimental condition in this experiment used a WTD known as the Water Pill (Finesse Performance, Los Angeles, CA). The Water Pill is a cylindrical, transparent plastic tube with handles attached to the sides. By filling it with water and air, the Water Pill creates an unstable internal load through the displacement of water. For this study, the WTD was filled with water to 50% of its total capacity, corresponding to approximately 8.5 kilograms to balance instability while also ensuring adequate weight stimulus.

The control condition utilized a custom-made resistance tube. To ensure that the control condition adequately approximated the experimental condition, a single Water Pill unit was disassembled by removing the end caps. A mailing tube was inserted centrally into the Styrofoam discs. The internal cavity was then filled with several stacked Styrofoam discs to replicate the typical volume of the device, as well as to hold the mailing tube in place. Sand and metal weights were added to the mailing tube until the total weight of the control device matched that of the WTD (8.5 kilograms). Once the desired weight was achieved, the ends were resealed to ensure structural integrity and to prevent the internal movement of the weight. These steps were taken to ensure that both conditions were identical in size, shape, and handling, differing only in the presence (experimental) or absence (control) of fluid movement.

Figure 1. Water Pill (above) and Static Control (below) used in the experiment.

Statistical analysis

Descriptive statistics are presented as median and interquartile range (IQR). Data deviated significantly from normality per Shapiro-Wilk tests. Wilcoxon signed rank-tests were utilized to compare control and intervention data within each group. All tests were two-tailed. Statistical significance was determined if $p < .05$ after employing a Holm-Bonferroni correction to control the familywise error rate. Effect size was determined as Cohen's d, along with 95% confidence intervals (CI). All analyses were performed using R version 4.5.0 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

All twelve participants successfully completed both training sessions, including one session with the water-filled resistance training device (WTD) and another session with the control device (CON), with ≥ 48-hours in between sessions. No significant differences were observed in mean ($p = .182$) or maximum rectus abdominis activation ($p = .328$) between sessions. However, the WTD condition demonstrated a significantly greater mean ($p = .002$, d = 0.95) and maximum ($p = .002$, d = 1.59) activation of the external oblique compared to CON (Table 1).

Both increases were associated with large effect sizes as determined by Cohen's d. Mean external oblique activation was approximately 85% greater in WTD relative to control (71.8 ± 36.0 μV versus 38.8 ± 21.2 μV, respectively). Maximum external oblique activation was approximately 77% higher in WTD compared to control (258.2 ± 102.5 μV versus 145.8 ± 77.5 μV, respectively).

Table 1. External oblique and rectus abdominis mean and max activation values.

Group	**External oblique activation**				**Rectus abdominis activation (µV)**			
	Mean (µV)	*p*-value	Max (µV)	*p*-value	Mean (µV)	*p*-value	Max (µV)	*p*-value
CON	38.8 (21.2)	.002	145.8 (77.5)	.002	11.5 (24.5)	.182	40.0 (70.3)	.328
WTD	71.8 (36.0)		258.2 (102.5)		13.7 (20.4)		44.5 (82.9)	

DISCUSSION

The results of the study demonstrated that using a water-filled resistance training device (WTD) during a rotational core exercise significantly increased muscle activation in the external obliques (EO) compared to a static weight control but did not show any significant increases in activation of the rectus abdominis (RA). The mean and maximum EO activation was 85% (*p* = .002, d = 0.95) and 77% (*p* = .002, d = 1.59) greater, respectively, in WTD compared to CON. However, differences in mean and maximum rectus abdominis (RA) activation between WTD and CON were nonsignificant. These findings partially support our hypothesis, which proposed that the WTD would significantly enhance core muscle activation in the rectus abdominis and external oblique relative to a static weight device. The significant increase in activation for the EO only and not the RA suggests that while the WTD's unstable load demands led to heightened core muscular engagement relative to CON's stable load, its efficacy may be restricted to certain muscle groups.

Although the Russian twist movement investigated in this study is designed to directly target the core, our findings align with broader research demonstrating that instability—particularly when introduced through water-filled implements—enhances core muscle activation even during exercises not primarily focused on the core. For instance, one paper reported a significant increase in rectus abdominis activation when participants performed bicep curls using a dynamically flowing water-filled tube (Glass et al., 2016). Despite not being the directly targeted muscle of the exercise, this finding suggests that the shifting water necessitates at least a partial compensatory response from trunk musculature in order to maintain balance. Similarly, another paper found that bench pressing with a water-filled tube elicited a near five-fold enhancement in core muscle activation (as measured by %MVC) compared to using a traditional barbell (Nairn et al., 2015). These findings, along with our own, support the premise that water-based instability elicits a compensatory response from both deep (e.g. transversus abdominis) and superficial (e.g. external oblique) core stabilizers, regardless of whether the movement is inherently core-focused.

However, the efficacy of instability training in enhancing core activation has long been debated. For instance, Anderson & Behm (2004) found similarly to our results that while performing upper-body exercises on unstable surfaces (e.g. Swiss balls), rectus abdominus muscle activation was not significantly different relative to a firm surface (e.g. flat bench). Additionally, Cressey et al. (2007) noted that instability can reduce the amount of external load that can be used during resistance exercises, potentially limiting hypertrophic gains in the primary target muscles. In these cases, the increased neuromuscular demand placed on the core—likely driven by anticipatory postural adjustments—may come at the expense of training other muscles involved in completing the exercises. As such, the mechanistic demands of using the WTD during the Russian Twist exercise, which emphasize rotational and lateral stabilization rather than trunk flexion, provide a plausible explanation for the non-significant difference observed in the rectus abdominis, a primarily flexion-oriented muscle.

In core-focused rotational movement exercises, both the rectus abdominis and external obliques are recruited to support trunk stability and proper spinal alignment during dynamic movements. Among other activated muscles such as the transverse abdominis, the RA maintains trunk flexion, while the EO contributes to lateral flexion and rotation (Oliva-Lozano and Muyor, 2020). The activation of these stabilizing core muscles can be categorized into the central nervous system's anticipatory (APA) and compensatory (CPA) postural adjustments. APAs refer to the activation or inhibition of trunk musculature prior to anticipated balance perturbations. In contrast, CPAs are reactive responses that activate or inhibit trunk musculature initiated by post-perturbation sensory feedback (Santos et al., 2009).

Traditional static resistance exercises demonstrate greater APAs, as the predictability of these exercises allows the body to prepare. However, the unpredictable, dynamic fluid movement of instability devices, such as the WTD, results in greater CPAs (Santos et al., 2009). The device's unpredictability elicits greater proprioceptive and neuromuscular demands, recruiting both deep and superficial core stabilizers to rapidly restore trunk stability during rotation. The reactive mechanism elicited by instability devices underscores our study's demonstration of heightened core muscular engagement when utilizing water-based instability training.

Water-based instability training may be leveraged for rehabilitation, specifically in programs designed to improve postural control and core muscle activation. The present study's use of the simple Russian Twist exercise allows it to be incorporated into nearly any array of existing programs. The instability engages more motor units than static weights, offering significant use for patients unable to walk or readily activate their core without risk of injury (Glass et al., 2016). Additionally, the unpredictability introduced by the device better mirrors the functional demands of daily life, which are key to practice for recovering patients, compared to isolated static movements (Rozevink et al., 2021). The increased substitution of weight for instability offers promising results for more holistic muscle activation and key motor activation in clinical and rehabilitation settings (Rozevink et al., 2021).

Additionally, water-based instability training presents a significant opportunity for athletes to improve existing techniques for both routine and rehabilitation training. Our results, along with those of similar studies have shown increased activation of the rectus abdominis and other core muscles when using water-based instability modalities (Glass et al., 2016; Ditroilo et al., 2018).The relevance of heightened activation of core musculature to athletes has previously been demonstrated and has been shown to improve general athletic performance due to improved core endurance and balance (Yu et al., 2025). Further research also suggests that core training can lead to improved performance in select sports, including football, basketball, and golf (Luo et al., 2022), with general increases in physical strength and smaller increases in speed, agility, and power (Dong et al., 2023). Given the impact of core muscle training on athletic performance, further experimentation could evaluate the relevance of water-based instability training for enhancing control and stability-maintenance abilities in athletes of different respective sports.

Limitations

The present study is limited by the use of a small, homogenous sample size. Data was collected exclusively from male, college-aged, apparently healthy individuals. As such, interpretations of results should be limited to this demographic, as it is unclear if the effects shown in the study are generalizable to all populations. Given the short duration of the study, additional longitudinal research is necessary to understand the long-term impacts of using the water-filled resistance training device (WTD) on core muscle activation during training. Further limitations include the use of a single weight (18.8 pounds), making it unclear if the observed effects persist at different intensities. Lastly, while sEMG is validated for surface-level muscle activity, it may be affected by outside factors, including body fat and body water content.

CONCLUSION

The present study investigated the effects of a water-filled resistance training device (WTD) on core muscle activation during a rotational core exercise, specifically targeting the rectus abdominis and external obliques. Results demonstrated that both mean and peak muscle activation were greater when participants used the WTD compared to a static-weight control, suggesting that instability-based resistance can elicit higher levels of neuromuscular engagement. These findings support the potential use of water-filled resistance devices in enhancing the efficacy of core training. For individuals aiming to improve trunk stability and muscular activation, incorporating dynamic, fluid-based resistance may provide a valuable supplement to traditional resistance training protocols.

AUTHOR CONTRIBUTIONS

All authors meet the criteria for authorship in accordance with established ethical guidelines. The study was conceived and designed by D. C. and B. A. D., whereas S. T., J. T., N. T., J. J. B., and J. H. performed data collection. P. G., T. Y., E. V. N., J. A. K., and B. A. D. completed data analysis. P. G., T. Y., J. A. K., D. C., and B. A. D. interpreted data and composed the manuscript, while S. T., J. T., N. T., J. J. B., J. H., and V. S. made crucial edits. All authors have critically reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

AI USE DISCLOSURE

In accordance with current publishing ethics and transparency recommendations, artificial intelligence (AI) tools were used solely to assist with translation and language editing, with the aim of improving clarity and readability. No AI tools were used in the generation of scientific content, including the study design, data collection, analysis, interpretation of results, or the formulation of conclusions. The authors retain full responsibility for the content of the manuscript and confirm its originality, integrity, and accuracy.

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