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Research article

Professional Soccer Player Neuromuscular Responses and Perceptions to Acute Whole Body Vibration Differ from Amateur Counterparts

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Abstract
Acute whole body vibration (WBV) is an increasingly popular training technique amongst athletes immediately prior to performance and during scheduled breaks in play. Despite its growing popularity, evidence to demonstrate its effectiveness on acute neuromuscular responses is unclear, and suggestions that athlete ability impacts effectiveness warrant further investigation. The purpose of this study was to compare the neuromuscular effects of acute WBV and perceptions of whether WBV is an effective intervention between amateur and professional soccer players. Participants were 44 male soccer players (22 professional and 22 amateur; age: 23.1 ± 3.7 years, body mass: 75.6 ± 8.8 kg and height: 1.77 ± 0.05 m). Participants in each group were randomly assigned to either an intervention of 3 x 60 s of WBV at 40 Hz (8mm peak-to-peak displacement) or control group. Peak knee isometric force, muscle activation and post activation potentiation (PAP) of the knee extensors along with self-report questionnaire of the perceived benefits of using the intervention were collected. A three-way ANOVA with repeated measures revealed professional players demonstrated a significant 10.6% increase ($p < 0.01$, *Partial Eta*^{2} = 0.22) in peak knee isometric force following acute WBV with no significant differences among amateur players. A significant difference ($p < 0.01$, *Partial Eta*^{2} = 0.16) in PAP amongst professional players following acute WBVT was also reported. No significant differences amongst amateur players were reported across measurements. Results also indicated professional players reported significantly stronger positive beliefs in the effectiveness of the WBV intervention ($p < 0.01$, *Partial Eta*^{2} = 0.27) compared to amateur players. Acute WBV elicited a positive neuromuscular response amongst professional players identified by PAP and improvements in knee isometric peak force as well as perceived benefits of the intervention, benefits not found among amateur players.

Key words: Potentiation, power, strength, perceptions.

Introduction

Whole body vibration (WBV) has been suggested as an attractive and time efficient complement to traditional forms of exercise for an athlete prior to performance (Cochrane, 2011, 2013; Ronnestad and Ellefsen, 2011). WBV evokes muscle contractions via tonic vibration reflex (TVR) through tendon vibration (Rittweger, 2010). The change in muscle length during vibration is detected by muscle spindles and induces a non-voluntary muscular contraction (Rittweger, 2010). An enhancement of the stretch-reflex, proposed improvements in neuron excitability and motor unit recruitment of the muscle are cited as reasons for improvements in strength and power output (Bosco et al., 1999). However, other mechanisms such as muscle temperature (Cochrane et al., 2008), blood flow (Kerschan-Schindl et al., 2001) and post activation potentiation (PAP) (Cochrane et al., 2010) have also been suggested as contributing factors. Yeung et al. (2014) suggest that these mechanisms are seldom investigated in acute WBV settings and suggest that if immediate muscle facilitation is the result of homonymous α -motoneurons activation, the effect should be seen in force output and motor unit recruitment. An observation not detected by Yeung et al. (2014) who reported no change in quadriceps stretch-induced reflex or peak force, findings consistent with other researchers who have also questioned the effectiveness of acute WBV (Hannah et al., 2013).

Acute WBV has been investigated as a potential ergogenic aid amongst coaches to induce immediate performance benefits prior to performance (Bullock et al., 2008) or during half-time rest periods in soccer to help prepare for the second half performance (Lovell et al., 2013). Towlson et al. (2013) discuss how 58% of Premier League/Championship football team practitioners incorporated half-time re-warm up strategies and Russell et al. (2015) suggest a PAP activity should be incorporated during the final 5 minutes of a half-time scenario in team sports. Any additions to a warm up routine should be carefully selected as these could contribute to an increased risk of fatigue leading to a decrease in performance or increased injury risk (Impellizzeri et al., 2013). Level of conditioning of the athlete should also be considered when implementing an acute conditioning exercise with the aim of PAP due to initial strength levels being dependent on the success of the intervention (Chiu et al., 2003; Seitz et al., 2014; Seitz and Haff, 2015). Depending on the extent of the pre-conditioning activity, the muscle’s impending activation can either be impaired by fatigue or enhanced by a phenomenon known as PAP (Sale, 2002), through a combination of neurogenic and non-neurogenic responses (Sale, 2002). This is seen by coaches as a particularly positive quality when preparing athletes for competition. Rittweger et al. (2003) identified increases in mean power frequency during sustained isometric contraction of the vastus lateralis after acute WBV. The authors suggest a central nervous recruitment of predominantly large motor units to maintain force output following acute WBV (Rittweger et al., 2003). Torvinen et al. (2002) identified that an acute bout of WBV improvements in strength and power of the lower extremities suggesting neural adaptations may have occurred, the authors note that the acute WBV was long enough (4 minutes) to stimulate without fatiguing the muscle.

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The idea of non-neurogenic factors such as potentiation of muscle twitch force has been suggested with electromyography (EMG) (Bosco et al., 2000), and Cochrane et al. (2010) identified that acute WBV induces PAP via non-neurogenic twitch potentiation and not neurogenic twitch potentiation. Jordan et al. (2010) however questions the influence of PAP following bouts of acute WBV, indicating an attenuation in knee extensor peak force values, not an improvement. These findings suggest further investigation is warranted into twitch potentiation and non-neurogenic factors following acute WBV. Knee extensor twitch potentiation has been correlated with improved performance in sprint and counter movement jump in elite soccer players (Requena et al., 2011).

A large amount of the current WBV research has used non-elite/moderately trained or sedentary populations as participants, with a few notable exceptions (Bullock et al., 2008; Cochrane and Stannard, 2005; Despina et al., 2013; Issurin and Tenenbaum, 1999; Lovell et al., 2013; Ronnestad, 2009). This has highlighted the need to investigate the different responses amongst different groups and possibly sub-groups and the underpinning neuromuscular effects (Ronnestad and Ellefsen, 2011). One specific group of interest is the difference between amateur and elite athletes. Evidence demonstrates that amateur and elite athletes differ in responses to WBV, with elite athletes showing greater increases in force output, muscle sensitivity to stimulus and balance (Cloak et al., 2014; Ronnestad, 2009). Further, Cloak et al. (2014) suggested acute WBV may impair balance and landing stability amongst amateur soccer players due to fatigue, in comparison to elite soccer players' balance and landing stability. Cloak et al. (2014) speculated differences between groups were attributed to differences in strength levels and neuromuscular responses to WBV. Isometric peak force output of the knee extensors has been identified as a distinguishing strength characteristic between professional and amateur soccer players, with professional players producing significantly higher values then amateurs (Gissis et al., 2006).

Few studies have compared perceptions of benefits of acute WBV between trained and untrained individuals. Belief effects are typically studied under the rubric of examining a placebo effect, defined as positive outcome arising from the belief that a beneficial treatment has been received (Beedie and Foad, 2009). Rønnestad et al. (2013) identified improved sprint performance related to perceived improvement in feeling of well-being in the legs following acute WBV in elite ice-hockey players. Marin et al. (2015) reported that untrained participants indicated a higher RPE when exposed to acute WBV at 50Hz compared to 30Hz and recommend 30Hz for untrained individuals. Beliefs in the likely effectiveness of an intervention or ergogenic aid have found to have an incremental effect on performance (Beedie and Foad, 2009). Individuals who positively believed that an intervention will be effective appear to gain greater benefits than participants who do not. Results of Beedie and Foad (2009) suggest that a belief effect could shape the efficacy of an intervention. Therefore, it seems prudent to assess beliefs in the effectiveness of an intervention during the evaluation. Assessing beliefs is becoming used more regularly in applied research. For example, Finch (2011) proposed monitoring athletes via self-report measures to try to identify perceived benefits on training interventions for injured athletes.

The aim of the present investigation, therefore, was to compare the acute effects of WBV amongst professional and amateur soccer players on muscle activation, PAP and peak isometric force of the knee extensors during a maximal voluntary contraction (MVC) and the perceptions of benefits of the intervention between groups.

Methods

Participants

Forty-four male soccer players (age 23.1 ± 3.7 yrs., body mass 75.6 ± 8.8 kg and height 1.77 ± 0.05 m) volunteered to take part in this study. The 22 professional players (English Football League 1) (age 24.1 ± 3.8 yrs., body mass 77.1 ± 7.4 kg and height 1.78 m ± 0.07 m) on average trained 12-14 hours per week and played one or two games a week for the previous 3-5 years. The 22 amateur players (age 22.1 ± 3.4 yrs., body mass 74.1 ± 9.9 kg and height 1.76 ± 0.06 m) on average trained between 3-6 hours per week and played up to one game per week over the previous season. All players reported to be free from injury, including concussion or mild head injury within the last year and no reported musculoskeletal injury within the last three months prior to the study. All participants had a minimum of 1 year's regular strength and power training and two days before familiarisation and testing days participants were instructed to minimize strength and power training involving the lower body and avoid adrenergic-enhancing substances, such as caffeine (Chiu et al., 2003). This research protocol was approved by the University Ethics Institutional Review Board of the University of Wolverhampton. All participants completed baseline measurements for peak isometric force, muscle twitch force and voluntary muscle activation during knee extension isometric MVC. Within each treatment group participants were randomly assigned using a sealed envelope method to either a control or WBV intervention. The final groups where made up of 22 professional players (11 WBV and 11 controls) and 22 amateur players (11 WBV and 11 controls). A 30-min rest interval separated the baseline measurements and the beginning of the intervention and subsequent post-intervention neuromuscular testing to allow for sufficient recovery (Jordan et al., 2010). An overview of the study design can be seen in Figure 1.

Participant preparation and electrical stimulation

All participants were seated with hips and knees flexed at 90 degrees. Participants where strapped in to prevent unwanted movement using an adjustable waist and shoulder belt, and arms were across the chest. Participants were positioned in a custom made chair designed for isometric testing of the knee extensors, in a upright position with 85° hip flexion and knee at 90° flexion using full knee extension as 0° reference angle. Testing was only con-

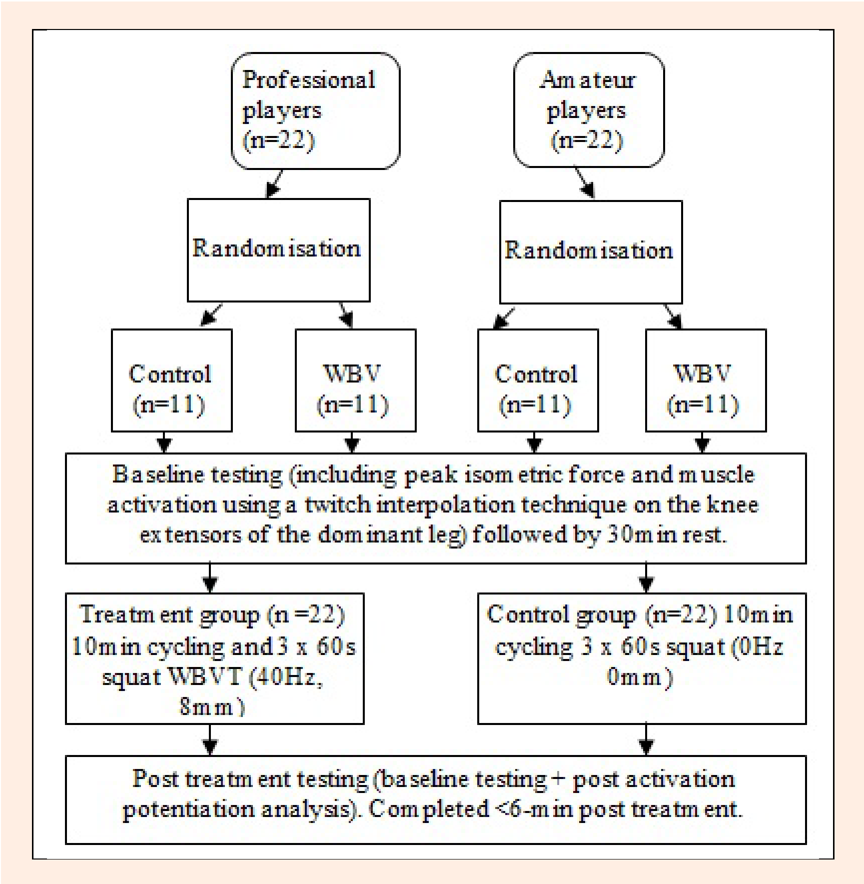

Figure 1. Overview of study design.

ducted on the participant's dominant leg. Their ankle was secured to an ankle holder attachment. The ankle holder was connected to a load cell (LCM Systems Ltd, UK) and DC amplifier. The load cell was calibrated before each testing session and secured to an anchor point behind the chair, with all forces recorded using a data acquisition system LabChart 7 Pro Software (PowerLab System, ADInstruments).

A familiarisation session took place the week prior to testing, participants were asked to abstain from any physical activity two days before each testing session (Jordan et al., 2010). The familiarisation included preparation of the participant's skin, fastening of the electrodes, and adjustments were made to the isometric chair which was recorded for future tests in preparation for the MVC. Two 5 x 8 cm self-adhesive surface electrodes (Valu-Trode electrodes, Axelgaard Manufacturing Co. Ltd., Fallbrook, CA) where placed on the distal and proximal areas of the quadriceps muscle group. Skin preparation involved shaving, gentle abrasion and cleaning with alcohol wipes. To ensure that electrode placement remained the same throughout, testing positions where marked on the participant using a marker pen (Cochrane, 2011). During the familiarisation session, participants were trained to perform MVCs with approximately 5-10 attempts taken to obtain a reliable MVCs (i.e., with no more than 5 % variation between the last trials) (Neyroud et al., 2014). Each received verbal encouragement (to ensure a maximal effort was given for the MVC) by the same member of the research team, and this was done throughout familiarisation and testing. Maximum twitch response was determined with a single 200us pulse generated by a high-voltage stimulator (DS7AH, Digitimer, Hertfordshire, UK). This involved increasing the twitch voltage in 50-100mA steps until a plateau in twitch force was reached. This value was noted and used during the subsequent testing (Cochrane et al., 2010).

MVC of isometric knee extension and twitch interpolation technique

The twitch interpolation technique was used in this investigation to assess neuromuscular function. The higher the percentage score indicates a greater ability to voluntarily recruit motor units. Three doublet twitches were given to the relaxed quadriceps muscle through a set of electrodes attached to the muscle belly (DS7AH, Digitimer, Hertfordshire, UK). The mean force (measured by a load cell in a seated position) produced by these three twitches represented the resting twitch force (RTFpre). The participant then performed a MVC that was held for 7 seconds (Jordan et al., 2010). At the fourth second of the voluntary contraction, when a steady-state force had been reached, another doublet twitch was applied eliciting the interpolated twitch force (ITF). Following the MVC three additional doublet twitches were given to the relaxed muscle (RTFpost). The protocol used has been described elsewhere (Jordan et al., 2010; Suter et al., 1998). Voluntary muscle activation during the MVC was calculated as follows: Voluntary muscle activation% = [1-(ITF/RTFpre)] x 100.

The presence or absence of PAP following the treatment conditions was calculated by dividing the post-treatment resting muscle twitch force (RTFpost) by the pre-treatment resting muscle twitch force (RTFpre). This value was then multiplied by 100% and subtracted from 100. This process has also been used by Jordan et al., (2010) when examining the effects of acute WBV (PAP = (RTFpost/RTFpre x 100) – 100). Post intervention (<6min) the participants were returned to the isometric chair for retesting.

Whole body vibration (WBV) protocol

All participants began with 10 minutes on a cycle ergometer between 65 and 85% of age-predicted maximum heart rate. An effort was made to achieve the specified heart rate range within 2 minutes of initiating exercise and revolutions per minute were kept between 60-80 rpm (Kelly et al., 2010). After 10 minutes the WBV group performed a 100-degree squat (as verified with a clinical goniometer) (Cloak et al., 2014). Once knee angle was fixed participants were asked to raise their heels as much as possible, once the position was standardised for each participant it was monitored using a clinical goniometer during trials to maximise vibration stimulus (Di Giminiani et al., 2012). Participants were exposed to a vertical sinusoidal WBV of 40Hz (8mm peak-to-peak displacement) (Cloak et al., 2014) (NEMES-Bosco, Italy). The WBV group completed 3 x 60 seconds with 60 seconds rest between trials as previously used in acute WBV setting in athletic populations to elicit high power output (Bullock et al., 2008), and the control group performed an identical warm up, however the squat was performed in the absence of vibration.

Self-report measures of perceived benefit of treatment

A self-report measure was developed specifically to assess perceived benefits of the different treatments amongst players. Participants used a 9-point scale anchored by 1 “not at all” to 9 “very well” in response to the question “To what extent do you think your treatment helped you perform today?” post intervention. This approach to assessing self-reported measure of performance has been used in previous research (Lane et al., 2002) and offers a simple method of developing bespoke measure albeit one where the inherent subjectivity in responses represents a challenge. It is suggested that self-report measures be used as estimates of performance and should not be treated as directly observable concepts (Nisbett and Wilson, 1977).

Statistical analysis

Independent sample t-tests were used to identify baseline knee isometric peak force differences between professional and amateur players. Knee isometric peak force (N) and muscle activation were analysed using a three-way ANOVA with repeated measures. The two between-subject factors were ‘playing level’ (professional vs. amateur) and ‘treatment’ (vibration vs. control) whilst the within-subject factor was ‘time’ (pre vs. post-intervention). A univariate ANOVA was used to investigate differences post treatments in PAP and perceived benefits of intervention amongst groups (between-subject factors were ‘playing level’ and ‘treatment’). Statistical significance was set at $p < 0.05$. Further, effect sizes (Partial Eta^2) were calculated and interpreted based on the criteria of Cohen (1992) where 0.1 is a small effect, 0.25 is a medium effect and 0.4 is a large effect. An intraclass correlation (ICC), was employed to determine the inter-session reliability (Shrout and Fleiss, 1979). Test-retest reliability was assessed by comparing the mean of the dependent variables between testing sessions (familiarisation and test day). The ICC test—retest reliability of knee isometric peak force (r = 0.962) and muscle activation (r = 0.943) was significant (p < 0.001), indicating little variability and thus a high degree of consistency attained between testing sessions. The Shapiro-Wilk statistic for each condition confirmed that the data were normally distributed. All statistical procedures were conducted using SPSS 20 (SPSS Inc., Chicago, IL, USA).

Results

Twitch interpolation analysis

Repeated ANOVA of knee isometric peak force identified a significant 3-way ‘playing level’-by-‘treatment’-by-‘time interaction ($F_{1, 40}$=11.09; p = 0.002, *Partial* Eta^2 = 0.217), As can be seen in Table 1, knee isometric peak force increased (10.6%) from pre-test to post-test in the professional WBV group, whereas there was a slight decrease in the amateur WBV group (-3.8%). Therefore, as illustrated in Figure 2, WBV had a significant effect on knee isometric peak force amongst professional players only. There were no significant main or interaction effects of muscle activation identified by the repeated ANOVA’s (p =0.259).

Univariate ANOVA of PAP identified a significant ‘playing level’-by-‘treatment’ interaction ($F_{1, 43}$=7.69; p =0.008, *Partial* Eta^2 = 0.161), with PAP amongst WBV professional players being 8.1% (±5.4) and -4.2% (±4.2) amongst amateur players (Table 1). An independent sample t-test indicated a significant (p = 0.02) difference in pre knee isometric peak force (N) between all professional (427.2 ± 197.4) and amateur players (317.1 ± 38.7). Finally, a univariate ANOVA of perception of benefit of intervention used on the day identified a significant ‘playing level’-by-‘treatment’ interaction ($F_{1, 43}$=14.56; p < 0.001, *Partial* Eta^2 = 0.267). With perceived benefits of intervention amongst WBV professional players being mean scores of 8 ± 1.2 and 5.9 ± 1.1 amongst amateur players.

Discussion

The aim of this study was to compare the effect of acute WBV on peak isometric force, muscle activation and PAP between professional and amateur soccer players. We also looked to investigate the perceived benefits of acute WBV across the different populations (professional and amateur). The results of the present investigation indicate acute WBV significantly improves peak knee isometric force with the presence of PAP amongst professional players in comparison to amateur counterparts; the latter

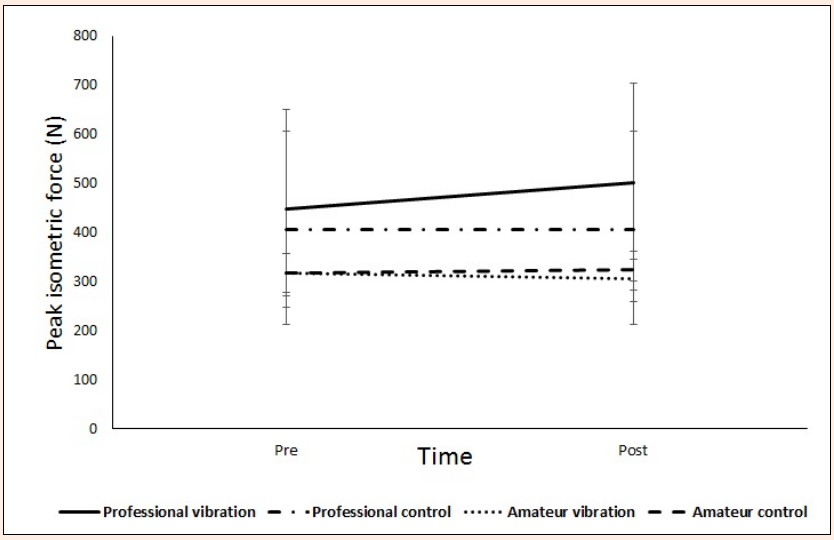

Figure 2. Peak isometric force 'playing level'-by-'treatment'-by-'time interaction.

showed no significant improvement in peak knee isometric force or the presence of PAP. The professional players reported a significantly more positive perception of acute WBV as a beneficial intervention in comparison to amateur players. Finally, neither professional nor amateur players showed any significant changes in muscle activation following acute WBV.

It has been previously reported that acute whole body vibration has a positive effect on performance with it being considered as a possible warm-up tool (Cochrane, 2013). One of the proposed mechanisms of improvement in performance is an increase in muscle activation via neurogenic potentiation based on the tonic vibration reflex (Rittweger et al., 2003). Our results showed improvements in knee isometric peak force and PAP amongst professional players following acute WBV compared to amateur players. The results suggest some key findings; firstly the increase in knee isometric peak force appears to be related to PAP rather than increased muscle activation. The results are in line with the findings of Cochrane et al. (2010), who also reported peak knee isometric force improvements following acute WBV. It would appear that the improvement in muscle RTF suggests phosphorylation of myosin regulatory light chains making contractile proteins more sensitive to the intracellular Ca^{2+} signal (Sweeney et al., 1993). This would result in greater cross-bridge interaction for the same intracellular Ca^{2+} concentration, which in turn increases the muscle tension for the same absolute level of neural stimulus (Szczesna et al., 2002). Although myosin light chain phosphorylation was not assessed the improved force output (with no change in overall muscle activation levels) does suggest a strong non-neurogenic component, as previously suggested by Cochrane et al. (2010).

Another possible reason for no significant change in overall muscle activation but an increase in knee isometric peak force, is the type of muscle fibres activated following acute WBV. Rittweger et al. (2003) suggests neuromuscular improvements after vibration exercise is most likely due to an enhanced excitability of fast twitch fibres and motor units. Pollock et al. (2012) suggests a combination of larger motor unit stimulation (and a reduction of fast-twitch fibre thresholds following WBV), an account that would explain no change in overall activation but a significant shift in fibre type recruitment within the current findings. The magnitude of the RTF after a conditioning contraction is a good representation of the activation of fast-twitch fibres during the conditioning contraction (Sasaki et al., 2012). The significant difference in pre-intervention knee isometric peak force score (N) between professional and amateur players illustrates the difference in strength profiles, with professional players displaying higher knee isometric force capabilities. It has been previously noted professional soccer players report significantly higher strength and speed characteristics (including isometric forces) compared to amateur players (Gissis et al., 2006). It has also been well documented that stronger individuals exhibit elevated myosin chain phosphorylation and tend to have larger/stronger type II fibres (Smith and Fry, 2007; Tillin and Bishop, 2009),

Table 1. Mean (and ±SD) changes in isometric peak force, muscle activation, perceived benefits and PAP amongst playing level (professional v amateur) and treatment group (WBV v control).

	Pre isometric peak force (N)	Post isometric peak force (N)	Pre activation %	Post activation %	Perceived benefit	PAP %
Professional WBV (n=11)	448.3 (202.3)	501.3 (199.8) *	84.6 (8.7)	87.3 (5.0)	8 (1.2) *	8.1 (5.4) *
Professional control (n=11)	406.2 (199.8)	406.7 (193.2)	86.5 (3.3)	85.5 (4.6)	6.3 (1.7)	2.5 (5.3)
Amateur WBV (n=11)	316.3 (41.4	304.8 (45.4)	84.6 (8.7)	84.3 (4.9)	5.9 (1.1)	-4.2 (4.2)
Amateur control (n=11)	318 (37.8)	323.4 (40.2)	82.1 (3.2)	82.3 (2.3)	7.1 (1.0)	-1.5 (4.6)

* Indicates significant difference ($p < 0.05$)

which have been proposed as a major factor in differences in potentiation effect between stronger and weaker athletes following a conditioning activity (Chiu et al., 2003; Seitz et al., 2014; Seitz and Haff, 2015). The standardised rest period following treatment (<6 min) may also have not been long enough for residual fatigue to subside and potentiation to effect power output in amateur/weaker athletes (Chiu et al., 2003; Seitz et al., 2014). Seitz et al. (2014) suggest that given the relationship between strength, PAP and fatigue, the stronger/better conditioned individuals may dissipate the residual fatigue quicker following a conditioning activity and therefore express PAP earlier as our results suggest. In order to validate this hypothesis further research which assesses the athletes over multiple time points is warranted.

Population differences may help to explain the disparity within WBV research. Yeung et al. (2014) identified no significant change in potentiation or peak force output of the knee extensors following an acute bout of WBV. However, it is acknowledged by the researchers that over a third of their participants did no regular exercise (37% n = 10) with none of the participants training regularly with a team or club (Yeung et al., 2014). Hannah et al. (2013) also reported no improvements in thigh muscle neuromuscular responses following acute WBV in fourteen healthy, recreationally active males not involved in systematic strength or power training. As with other studies investigating PAP it would appear that starting strength is an important factor when performing pre-conditioning activity (Chiu et al., 2003; Seitz et al., 2014; Seitz and Haff, 2015). It could be argued from the present set of results that this is also true when the pre-conditioning activity is WBV and not just traditional resistance exercise. Bullock et al. (2008) discusses the idea that muscle tendon complex of professional athletes are conditioned to minimize changes in muscle length and to damp vibrations and resist high-impact load; therefore higher WBV loads (>40Hz 8mm peak-to-peak displacement) potentially elicit a more positive response amongst well trained individuals (Issurin and Tenenbaum, 1999; Lovell et al., 2013; Rønnestad et al., 20009; 2013). Knee extensor isometric peak force is one of a number of strength profiling tests that could be used to assess initial strength levels between playing levels (Gissis et al., 2006). However, comparisons within the literature are difficult due to differing methodologies and testing set-ups, and its relation to soccer performance has been questioned (Requena et al., 2009). For a clearer understanding of how initial strength level impacts upon the effects of acute WBV a number of strength diagnostic tests should be included in future.

In the present study, results show that amateur players reported significantly lower scores on the perceived benefit scale from the acute WBV than professional players. Rønnestad et al. (2013) used self-report measures following acute WBV and elite ice-hockey players reported their legs feeling “good” following treatment as opposed to “normal” amongst controls prior to a subsequent significant improvement in 10 and 20m on-ice sprint performance. However, a limitation of the approach used in the present study was that beliefs were not manipulated positively (placebo treatment) and negatively (placebo treatment)(Beedie and Foad, 2009). However, the order of treatment and the control conditions were randomised and no information about potential effects of the vibration treatment was given to the participants. What is clear is that the amateur athletes did not perceive the WBV as beneficial as cycling alone, whereas the professional players did. The findings for amateur players might be linked to current training status and subsequent fatigue. As would be expected, elite players trained for more hours than amateur players. Therefore, it is plausible that among amateur players the load may have been too high and caused sensations of fatigue, as previously suggested (Marin et al., 2015). However, this was not assessed through further questioning.

In contrast, professional players perceived acute WBV as beneficial; the athlete’s perceived benefit, and convincing beliefs, can have an incremental effect on performance (Beedie and Foad, 2009). The incorporation of novel equipment to a task has also been seen to improve interest and enjoyment and motivation during training (Fitzgerald et al., 2010) . Marin et al., (2015) suggests lower frequencies (30Hz) may be perceived as more enjoyable amongst untrained and amateur athletes due to lower RPE and suggests it should be used to increase compliance and adherence. Perceptions of benefits of acute WBV interventions have received little attention in the literature. However, it would appear it may be an important issue when prescribing for different populations. If beliefs influence the initial success experience when using an intervention, this is likely to raise confidence and beliefs further that it is effective and, therefore, the intervention acts as a self-efficacy intervention (Beedie and Foad, 2009).

Conclusion

The current research is the first to our knowledge to demonstrate a significant neuromuscular difference in responses to acute WBV between professional and amateur soccer players. Although the exact mechanism for the increase in PAP and knee extensor peak force amongst the professional players is yet to be confirmed, the effect appears to be mediated by initial strength levels and possibly vibration frequency used. One limitation of the present research is the time course of any neuromuscular benefit. MacIntosh et al. (2012) discusses the lack of research looking at how long the benefits of PAP last and the practical application to prolonged athletic activity such as game play. Future research should focus on how the current protocol impacts on ultimate match performance either as a warm-up or half-time strategy, and whether a more in depth strength profile of each player would provide more information to differentiate how players respond to WBV. The difference in perceived benefits between professional and amateur players also highlights the need for future research to investigate the role of athlete perceptions of WBV benefits, as there appears to be a significant difference between athletic populations.

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Key points

- Acute WBV improves knee extensor peak isometric force output and PAP amongst professional and not amateur soccer players
- Professional players perceived acute WBV as more beneficial to performance than amateur players
- Isometric strength,vibration intensity and duration appear to influence results amongst players of different playing levels

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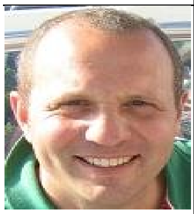

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