

In-season whole-body vibration training enhances vertical jump performance in professional soccer goalkeepers

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Abstract

Goalkeepers play an important role in soccer, often influencing match outcome. Soccer goalkeepers have superior jumping ability compared with their outfield counterparts and research has highlighted the importance of this ability. While there is evidence that whole body vibration training (WBVT) can improve explosive power in various populations, there is no data focusing on how this training modality may benefit soccer goalkeepers. With institutional ethics approval, 20 professional male soccer goalkeepers (age = 24 ± 6 yrs.; mass = 84 ± 10.3 kg; height = 1.84 ± 0.1 m) from the English Football League Division One were randomly assigned to either a WBVT or control group. The WBVT group performed static squats from their individual ready position, which is utilised by goalkeepers prior to performing any dynamic movements, on a vibration platform twice-a-week over a five-week period. The control group followed the same exercise programme without the application of vibration. Vertical jump performance, initiated from the goalkeepers' individual ready position, was measured prior to, and on completion of, the five-week study. A 2-way ANOVA with repeated measures showed an improvement in the experimental group's jump performance from 49.2 ± 4.4 cm pre-training to 53.8 ± 3.5 cm post-training, while the control group's performance remained stable from 47.02 ± 4.8 cm pre-training to 46.6 ± 4.5 cm post-training, resulting in a significant time-by-group interaction ($P < 0.001$). Findings of the current study provide evidence supporting WBVT's incorporation into goalkeepers' training regimes.

Keywords: Association football, exercise training, power, ready position.

INTRODUCTION

Professional soccer goalkeepers cover less distance in a game (~5.5 km) (12) than outfield players (~ 9-14 km) (3, 11, 28) though they are often involved in match deciding actions (12, 35). Hence, it is advantageous to maximise the performance of this specialist population. Due to lower metabolic loading (30), professional soccer goalkeepers have higher levels of body fat (12-14%) (2, 33) and lower maximal oxygen uptake (VO_{2max}) values ($50-57$ ml.kg.min⁻¹) (2, 33) compared with outfield players (8-12% and 59-63 ml.kg.min⁻¹ respectively) (2, 33). Goalkeepers are also generally taller (≥ 185 cm) (2, 18, 33) and have a larger body mass ≥ 81 kg (2, 7, 33).

Vertical jumping performance in particular is considered crucial as it allows the goalkeeper to more effectively collect the ball from an attacking cross or corner (1, 23). Goalkeepers have been shown to jump on average ~49 cm; considerably higher than their

outfield counterparts who reportedly jump to ~45 cm (33). Developing anaerobic power, manifested through a vertical jump, can therefore be viewed as an essential contributory factor to successful goalkeeping in soccer (33).

Traditional regimes, such as plyometric training and agility drills, have long been the mainstay of soccer goalkeepers when trying to improve jumping performance (4, 23, 36). While these approaches continue to be favoured by practitioners, recent research has reported enhancements in jumping performance following whole body vibration training (WBVT). The performance improvements associated with WBVT are believed to occur through physiological adaptations to accommodate vibratory waves (5, 29). However, the specific mechanisms by which WBVT can affect the musculoskeletal and other bodily systems remains the topic of much debate; some advocate the stimulation of

neuromuscular pathways and muscle spindles, while others claim that increased muscle temperature and hormone secretion are the primary contributory factors (17). From a practical perspective WBVT is time efficient, can be conducted indoors, involves reduced contact with the ground, is not effort based and can be easily regulated. It has also been previously demonstrated that a minimal WBVT intervention (≤ 10 mins per week) can have beneficial effects on performance without increasing the overall training load (39). Studies on sedentary and recreationally active populations (10, 15-16) have reported performance enhancement following relatively short-term (6-12 weeks) exposure to WBVT. However, WBVT's effectiveness in trained groups is less clear. Some studies, such as those using a dance population (39), have reported significant improvements in jumping performance with WBVT. Others, including one involving national league basketball players (14), reported no increase in jumping ability following a WBVT intervention. The reason for these discrepancies is not currently clear, although it is likely to be multifactorial; with differing protocols, the utilisation of various equipment for both training and testing, and the performance level of participants, all influencing results (15).

Given the importance of jumping performance to the soccer goalkeeper and the lack of data regarding WBVT relating to this specialist population, the aim of the current study was to determine the influence of this training modality in a professional population. Therefore, a mixed research design with independent, randomly assigned groups, undertaking different interventions, with repeated measures (testing pre- and post- the intervention period) was implemented.

MATERIALS & METHODS

Participants

Following institutional ethical approval, and in accordance with the latest delineation of the Helsinki declaration (37), 20 professional male soccer goalkeepers (mean \pm SD: age = 24 ± 6 yrs.; mass = 84 ± 10.3 kg; height = 1.84 ± 0.1 m) from the English Football League Division One were recruited. Goalkeeper recruitment was facilitated by members of the research team being actively involved in supporting performance enhancement and evaluation in profession soccer; enabling direct contact with clubs and players. By completing written informed consent forms and physical activity readiness questionnaires (PAR-Q), and through

verbal confirmation throughout the study, all goalkeepers self-reported that they were not suffering from any injuries or illnesses that would preclude participation.

Measures

Baseline vertical countermovement jump assessment

All goalkeepers underwent basic anthropometrical assessment, which included height (seca 213 stadiometer) and mass (seca 761 scales) measurements to the nearest 0.01 m and 0.1 kg respectively, while wearing training clothing (shorts and t-shirt). Goalkeepers were then instructed to adopt their "ready position", which soccer goalkeepers utilise to establish a strong, balanced and agile base prior to performing any dynamic movements (9, 22). All knee angles were measured manually using a goniometer (35) so that their individualised position could be adopted by both the WBVT and control groups during their training interventions *and* as the starting position for the jump performance testing, thus increasing ecological validity (Figure 1).



Figure 1. Initial measure of goalkeeper ready position.

The vertical countermovement jump (VCMJ) is a simple proxy marker of muscle power that was selected owing to its ease of measurement, existence of population norms, and frequency of use in applied

sports performance settings (20-21). Saliiently, VCMJ is a valid and reliable method of assessing body size-independent muscular power (25-26). All goalkeepers performed three maximal VCMJs on a contact mat (Just Jump™: Probotics Inc. USA), initiated from their individual ready position. Contact mats are considered to be a reliable method of assessing jump performance with high criterion validity (21) and have been utilised in a number of previous WBVT studies (10,14-16) and also to quantify jumping performance in a specific goalkeeping population (33). Jump height was calculated using the following equation (20):

$$JH = \frac{FT^2 \times g}{8}$$

Where JH = jump height; FT = flight time; and g = gravitation acceleration (i.e. 9.81 m.s⁻²).

Throughout the jumping process, goalkeepers were not permitted to initiate any arm swing, so as not to influence jump height (14-15). The highest baseline VCMJ was used for subsequent statistical analysis (8, 14-15).

Procedures

Goalkeepers were randomly allocated to either an experimental (WBVT) or control (no vibration) group. The WBVT group performed a static squat from their individual ready position on a NEMES Bosco vibration platform (NEMES-Bosco, Italy) twice per week for a five week period (Figure 2). Operating in a synchronous, vertical motion, the platform’s amplitude remained constant at 2mm throughout the study, while the frequency and training time were consistent with the overload training principle (19) and with previous studies investigating the effects of WBVT on VCMJ in a variety of populations (8, 10, 14-16). The control group followed an identical exercise regime, twice per week for five weeks, but in the absence of vibration (0 Hz, 0 mm). Training in the

current study was deliberately scheduled to coincide with goalkeepers’ lower-intensity training days with their respective clubs (Figure 3). Following previous findings regarding the effect of footwear on vibration transmission (24), all goalkeepers wore their own rubber-soled training shoes while undertaking WBVT. For consistency, all goalkeepers in the control group also adhered to this requirement. To ensure parity across the groups, no feedback was given to goalkeepers (in both experimental and control groups) regarding their jumping performance until all three trials were completed. Only guidance regarding correct positioning (e.g. knee angle relating to the ready position) or technique (e.g. ensuring knees remained extended in flight) were provided.



Figure 2. Static squat in the ready position on the vibration platform.

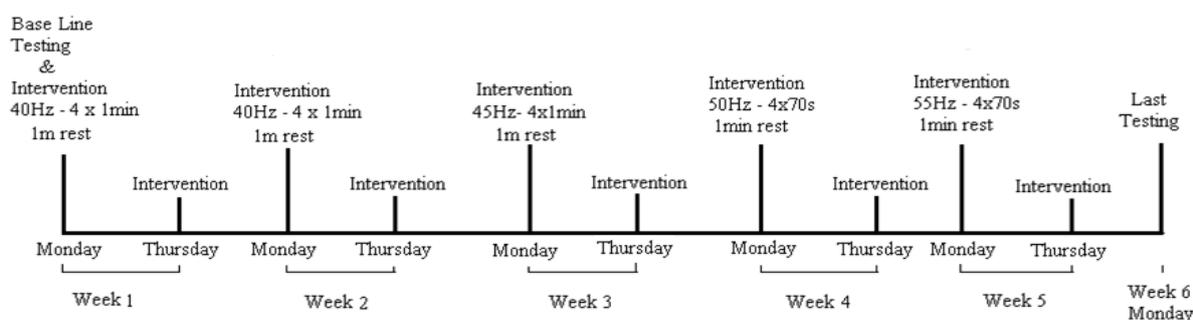


Figure 3. Vibration training protocol.

Post-Training Vertical Jump Re-Assessment

Goalkeepers' VCMJ performance was re-assessed 72 hrs following the last training session to allow for sufficient recovery (27, 37) and at a similar time of day (± 1 hrs) as the baseline assessment to avoid the confounding influence of circadian variation (13, 34). All goalkeepers performed three maximal VCMJs as per the baseline assessment; the highest value again used for analysis. As with the baseline jumps, no feedback regarding performance was provided until all trials were completed.

Statistical Analysis

A 2-way mixed model ANOVA was employed to assess within (pre vs post) and between (experimental vs control) subject main effects. If any significant F values were observed, Bonferroni post-hoc tests were performed to determine where any significant differences occurred. An alpha value of 0.05 was used for all tests. All statistical analysis was performed with the statistical package for social sciences (SPSS, v20, England).

RESULTS

Baseline

Our sample were anthropometrically comparable to professional goalkeepers' norms reported in the literature (33, 41) at baseline (see Table 1). An independent sample t-test revealed that there were no significant differences in VCMJ values between the experimental and control groups at baseline (see Table 1).

Table 1. Baseline anthropometrical and jump performance measures.

Parameters	WBVT Group (n=10)	Control Group (n=10)	Group P Value
Age (years)	24.5 \pm 7	23.6 \pm 7	0.74
Mass (kg)	83.52 \pm 11	84.41 \pm 7.5	0.84
Height (cm)	1.84 \pm 0.1	1.83 \pm 0.09	0.89
Jump Performance (cm)	49.2 \pm 4.4	47.02 \pm 4.8	0.33

Post-Training

Goalkeepers' VCMJ performance significantly differed by time ($P = 0.001$) and group ($P = 0.001$) (Figure 4). Specifically, VCMJ performance significantly increased from 49.2 ± 4.4 cm pre-training to 53.8 ± 3.5 cm post-training (mean difference: 4.6

cm) in the WBVT group. Contrastingly, VCMJ performance marginally decreased from 47.02 ± 4.8 cm pre-training to 46.6 ± 4.5 cm post-training (mean difference: 0.42 cm) in the control group (Figure 5).

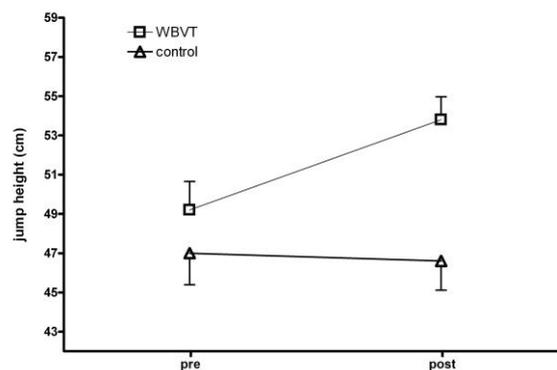


Figure 4. Pre- to post- absolute changes in jump performance.

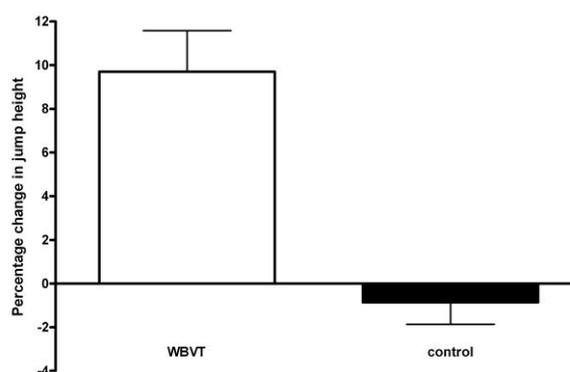


Figure 5. Pre- to post- percentage differences in jump performance.

DISCUSSION

There is a paucity of data appertaining to the performance implications of in-season WBVT in professional soccer goalkeepers. We addressed this unmet need, providing novel data demonstrating that five weeks of progressive in-season WBVT significantly enhanced VCMJ performance in professional soccer goalkeepers. This is important since jump performance is a key determinant of professional soccer goalkeeper performance, as reflected in goalkeepers typically exhibiting significantly higher VCMJ scores than outfield players (33, 41). Practically, our data suggest that short-term WBVT can be successfully incorporated into in-season soccer goalkeeper training regimes. This may be particularly attractive to practitioners

given the low time commitment (~ 8 min per session and ~ 80 min in total over five weeks) and ecological validity (jumps were performed from the ready position) of our WBVT paradigm. Training in the current study was deliberately scheduled to coincide with goalkeepers' lower-intensity training days with their respective clubs in order to: maximise the impact of the intervention, and, have minimal impact on other training. However, the improvement in jump performance of the current study's intervention group combined with previous research reporting that 6 weeks WBVT exposure did not 'overload' dancers (39) is encouraging for the prescriptive use of WBVT as an additional training modality without the concern of inducing unwanted loading or fatigue.

The 9% improvement in VCMJ in the WBVT group is comparable to previous literature reporting ~8-14% improvement in VCMJ post-training in healthy populations (10, 15-16). Interestingly, this result contrasts with previous findings in national level basketball players where six weeks of WBVT did not improve VCMJ performance (14). Comparisons with previous literature therefore, create two points that warrant explanation. The first is the similar increase in professional goalkeepers' jump performance compared with young healthy cohorts; and the second, is the discrepancy between improvements observed in goalkeepers but *not* basketball players. Both points may be explained by an adaptive threshold hypothesis, positing that an upper limit exists for VCMJ performance with short-term WBVT that depends on initial performance levels. In support of this, baseline VCMJ scores in basketball players (~52 cm) were similar to post WBVT scores in professional goalkeepers (~53 cm). The scope for adaptation in basketball players was limited, in congruence with jump training being a training staple in basketball (31-32, 40), whereas scope for adaptation existed in professional goalkeepers given their lower baseline level. We speculate that this permitted a similar magnitude of adaptation in professional goalkeepers despite greater absolute VCMJ performance compared with young healthy controls.

In a wider context, our findings suggest that current in-season soccer goalkeeper training regimes do not optimise VCMJ performance. In this regard, practitioners may wish, therefore, to supplement extant regimes with short-term WBVT. This is likely of practical value given the importance of jumping to soccer goalkeeper performance and the pivotal role this position plays in determining match outcome

(12, 36). Further, the use of an assessment and training paradigm that can be manipulated to maximise ecological validity through adoption of a ready position presents axiomatic advantages to the applied practitioner. Indeed, the adoption of a sports-specific ready-position likely contributed to the improvements observed here, as this self-selected position is likely where the optimum level of muscle activity occurs in order to produce maximum explosive muscle power on take-off from the VCMJ (20). This is of particular importance, when reviewing the findings of the current study, as it is recommended that optimal vibration frequency should be combined with optimal muscle activity levels during WBVT (6). For the current study though, it was decided that assessing whether or not a standard protocol could be recommended, without the need for establishing an optimal level of muscle activity, was sufficient.

Despite the encouraging results showing that WBVT can be an effective intervention strategy, our study is not without limitation. The use of contact mats as a measure for lower body power is not without controversy. While many have reported the reliability of contact mats, there remains debate over the validity of such systems. However, the reported reliability, the ease of use within a professional club environment (negating the requirement for players to attend the laboratory for testing), that the same systems were used for previous WBVT studies (14) and, crucially, for the quantifying of professional soccer goalkeeper jump performance (33), justified the research team's decision to utilise a contact mat system for the current study. Additionally, we were unable to control in-season training variables and thus do not exclude the possibility that this influenced our results. Controlling this was clearly difficult owing to the recruitment of goalkeepers from several different clubs that may not necessarily share homogenous in-season training practices. Whilst one cannot assume that this confounding influence equilibrated across groups, the lack of change in the control group supports the view that performance changes were largely attributable to WBVT.

Future studies may wish to explore the influence of vibration supplemented soccer training during pre-season at a single club wherein non-WBVT can be controlled, but this would be at the expense of sample size as clubs typically employ 2-3 professional goalkeepers. Outfield players are an obvious population to investigate further as this would allow

comparisons between different positions and from different levels (e.g. 1st, 2nd and 3rd team players and those from within the academy structures).

In conclusion, we have demonstrated, for the first time, that five weeks WBVT significantly improves in-season VCMJ performance in professional soccer goalkeepers, adding to the growing body of research supporting the efficacy of WBVT in improving proxy measures of muscle strength and power in a variety of populations. The use of such a high performance population, not readily available for research purposes, combined with the encouraging results from a relatively straightforward intervention augments the applicability of the current study's protocol. Additionally, the utilisation of the ready position, for both training and testing procedures, further enhances the ecological validity and applicability of the current study's findings. These findings, in combination with previous evidence of WBVT being appropriate as an additional training modality, with no detrimental loading, may encourage practitioners to supplement extant in-season soccer goalkeeper training programmes with WBVT.

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Conflict of Interest

No conflicts of interest are reported for this study.

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