The Effect of Low-Resistance High-Repetition Resistance Training on Longer-Term Functional Adaptations and Total Athletic Score

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Abstract

Purpose: To determine the effect of 52 weeks of low-load high-repetition resistance training (BODYPUMP™) on broader athletic performance in healthy adults. To identify if any relationship between the performance within the training program and athletic performance exists when measured independently.

Methods: Twenty-six, apparently healthy adults: four males (age = 51.6 ± 4.0 years; height 178.8 ± 13cm and body mass = 82.4kg ± 6.5kg) and twenty-twofemales (age = 38.3 ± 7.0 years; height 163.5 ± 6cm and body mass = 58.6kg ± 4.5kg)participated in and completed the yearlong longitudinal cross-sectional study. All participants had trained with BODYPUMP™ for ≥ 1 year; this was their solemethod of training which they attended on average a minimum of twice a week.Isometric mid-thigh pull (IMTP) peak force (PF), 10m sprint time, counter movement jump (CMJ) height and the total score of athleticism (TSA)were all assessed.

Results: Testing revealed that after 1-year total load (kg) relative to body weight (BW) has a strong correlation with isometric mid-thigh pull (IMTP) peak force (PF) (r=0.767), 10m Sprint (r=0.712), counter movement jump (CMJ) height (r=0.719) and the total score of athleticism (TSA) (r=0.721) as assessed by Pearson's correlation p <0.05.

Conclusions: This research demonstrates that BODYPUMP™ does have athletic carryover for some components of fitness (strength, power and speed). This study has shown that thetotal score of athleticism (TSA) is strongly correlated to lifting ability (r=0.721) within the training program.

Keyword: Athletic score, BODYPUMP®, Physical fitness, Resistance, Training.

INTRODUCTION

Strength is underpinned by a combination of morphological and neural factors including muscle cross-sectional area and architecture, motor unit recruitment, rate coding, motor unit synchronization, and neuromuscular inhibition. Although people generally recognise theoverall health benefits of strength training such as increased lean body mass and bone strength, theycannot always conform to the more traditionalstrength and conditioning (S&C) practices of heavy squats, weightlifting derivatives etc. So, with the continuing realisation of the importance of resistance training to overall health, coupled with the somewhat difficult nature of resistance training,group-based fitness trainingfocussed around low resistance high repetition (LRHR) training programs have increased in popularity.

However, low resistance load coupled to high repetition training and its applicability to both strength gains and wider athleticism is not clear[1–3]position stands and recommendations are made based on, we propose, limited evidence to lift heavier weights. In a recent review to identify underlying physiological factors and other training considerations (i.e., methods, loading

strategies, set configurations, and training status) that may affect muscular strength, development exercise programming combining heavy and light loads was seen to improve strength and underpin other strength-power characteristics[3] and had a significant utility in weaker or less-skilled individuals [2,3.] Although single- and multi-targeted block periodization models may produce the greatest strength-power benefits, within each model must be considered within the limitations of the sport, athletes or individual undertaking the training, and schedules must be undertaken. Bilateral training, eccentric training and accentuated eccentric loading, and variable resistance training may produce the greatest comprehensive strength adaptations. yet for many these modalities are difficult to incorporate into a "fit for purpose" lifestyle exercise regime. Training to failure may not be necessary to improve maximum muscular strength and is likely not necessary for maxi-mum gains in strength. Indeed, programming that combines heavy and light loads may improve strength and underpin other strength-power characteristics.

Les Mills BODYPUMP™ is 60-min full body low-load, high repetition resistance training group exercise class, in which the participants use a bar and self-selected weights. According to Les Mills International, globally there are over 17,000 Body-pump licenses operational. The class format has augmented the LRHRmode of training whilst also optimising the motivational and psychological benefits of group exercise as well as exercise to music[4,5] Past research has described the typical energy expenditureof a BP class[6,7] as well as various beneficial adaptations[8,9]. But

previous studies investigating the effects of BP have been limited owing to the principle outputs being strength, energy expenditure and/or anthropometric parameters[10,11]. Also commonly research exploring physiological adaptation in response to BP has been conducted with an intervention over a matter of weeks and usually with untrained participants[8,10]. Hence the main objective of this study is to discover if there is a long-term relationship between lifting ability within BP and athletic ability at the end of a year. It is hypothesised that there will be some correlation between overall weight lifted in class per kilogram of bodyweight (ranking) and relative neuromuscular performance (power, speed and strength) due to exercises performed with the highest intensity involving the posterior chain in compound lifting. Therefore, the primary aim of this study was to identify and if possible, quantify the associated athletic gains made via LRHR when using the Les Mills BODYPUMP™ format across a year.

METHODS

Four trained men and twenty-two trained women were enrolled in this study (see Table 1 for the participant characteristics). The participants were healthy and had previously participated in BODYPUMP™ (60 mins) for a minimum of two days per week (50/52), for at least one year prior to this study. All signed informed consents resultant from institutional ethical approvalwere collated from each participant prior to commencing the study. Ethical approval for this study was provided by MiddlesexUniversity ethical advisory committee.The study conformed to the standards set by the latestrevision of the Declaration of Helsinki.

Table 1. *Participant characteristics for Age, weight and height delineated by gender*

Participant characteristics		
Variable	Female	Male
Age (years)	38.3 ± 7.0	51.6 ± 4.0
Weight (kg)	58.7 ± 4.5	82.4 ± 6.5
Height (cm)	163.5 ± 6.1	178.8 ± 13.2

Data expressed as mean ± standard deviation.

To test the hypothesis that there is a relationship between lifting ability in class (sum of all weight lifted/ Bodyweight) and athletic performance the following experimental procedures where conducted pre-

class with a minimum 48hrs rest before testing: (a) explosive power (CMJ) and (b) horizontal speed (10m Sprint) and (c) isometric strength peak force (IMTP-PF). Participants were required to visit the testing

venue twiceacross a two-week period, where the order of each test within a given day was kept strictly the same for each participant regardless of the day they were testedas well as the tests being scheduled at exactly the same time of day per participant to account for diurnal variation in physiological status. The following testing battery was administered to the participants after 5-minute cycle ergometer warm-up (load free), coaching and familiarization. Week 1 tested the CMJ maximal height (3 attempts 60 sec rest between attempts) followed by the 10m speed gate test (3 attempts 60 sec rest between attempts) and week 2 tested the IMTP-PF(2 attempts at MVC 2mins rest between attempts) see Figure 1.
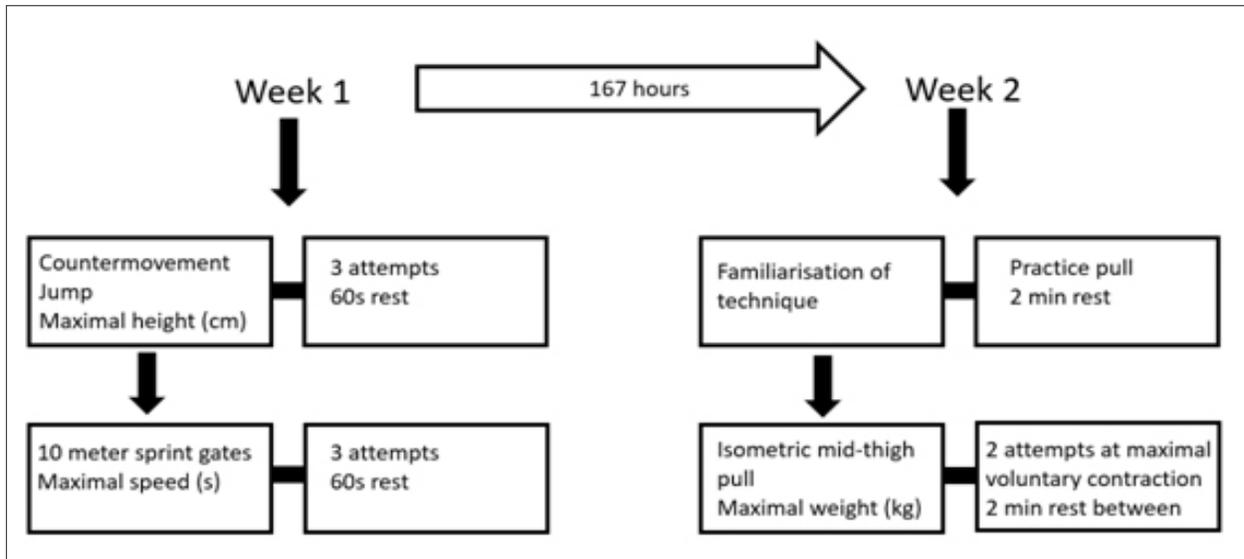

Fig 1. *Flow diagram showing the different stages and timings of each experimental session*

In order to assess explosive muscular power counter movementjump (CMJ) height was tested [24] on a Just-Jump matt. After completing a warm-up, each participant performed three CMJ trials squatting down to a self-selected height (approx. 90° knee flexion) before a subsequent concentric contraction (triple extension) to achieve maximum height by utilizing the stretch shortening cycle (SSC). The participants were instructed to keep their hands on their hips during the testing and to remain motionless before and after jumping with 2min rest time in between jumps. If the participant did not land entirely on the mat retests were administered. The CMJs were performed on a jump mat that calculates maximum height based on flight times. The values obtained from 3 separate jumps were used for data analysis and reliability.

The sprints were assessed using electronic timing gates (Brower timing systems, Salt Lake City, Utah USA) that record time to an accuracy of 0.01 seconds through 10 meters. Participants were given no assistance in relation to running techniques other than to be told they must break the final beam as fast as possible. The timer started from the moment they broke the first beam from a stationary position and ceased on the second beam breaking. The values obtained from 3 attempts were used for data analysis.

The mid-thigh pull was executed on a force plate (Kistler 9286AA with bioware software version 5.3.0.7) located within a smith machine with locking pins and ratchet straps to secure the bar as immovable. The force plate was calibrated and then sampled at a rate of 1000Hz. Participants were coached into the correct power position as prescribed by Garhammer (1993)[12]. Participants were instructed to pull "Hard and Fast" as this has been shown to provide optimal results when recording RFD and continue to pull maintaining the initial effort for 3 seconds with strong verbal encouragement[13,14]. Participants performed 2 trials with a minimum of 2 minutes rest in between the trails. The highest values of PF and RFDwere utilised in subsequent data analysis with the RFD being determined as the peak force when a plateau in the force-time curve was achieved divided by the time in which it took to accomplish the given force level. When considering ISO and dynamic measures, which did not account for body mass (i.e., absolute strength)

and the relationship to total load in class the greatest correlation existed (r = 0.854). However, in order to eliminate the athletic advantage of absolute strength due to body mass additional calculations have been applied to show relative strength by dividing PF by body weight (BW).

DATA ANALYSIS INCLUDING STATISTICAL ANALYSIS

The TSA (Total Score of Athleticism)[15]was calculated after the z-scores for each participantfrom the IMTP (peak force and rate of force development), CMJ and 10m sprintweregenerated. To achieve a z-score the data was converted to have a mean of zero and a SD of one. Thus a +2 would indicate that the participant would have scored above the mean by 2SD or the equivalent to better than 97%. Rank was determined by the participants maximum TSA, as composed of the z-scores with a normalised mean of 0 relative to PF, RFD, CMJ and 10m sprint, relative to the other participants. The maximal ranking was 0.Total load lifted (absolute strength) was the sum of themaximal lifting capacity for each specific exercise (nine in total). Total relative load lifted (load per kg body weight) was calculated by dividing the total load lifted by body weight for each individual participant.

Data were analysed with descriptive statistics using IBM SPSS software (version 23.0, SPSS, Inc., IL,), with results summarized as mean ± SD. The data were assessed for normality by Shapiro-Wilk's test. Intra-class correlation coefficient (ICC) was applied to provide an estimate of relative reliability between the variables. The Pearson product correlation coefficient (*r*) was utilised to assess the concurrent validity of the IMTP, CMJ and 10m Sprints. Correlations are categorised as *r* = trivial (0.0), small (0.1), moderate (0.3), strong (0.5), very strong (0.7), nearly perfect (0.9), and perfect (1.0)[16]. The criterion for statistical significance of the correlations was set at P ≤ 0.05.

Table 2. *Participants descriptive data of performance variables for strength and power measurements in the isometric mid-thigh pull, countermovement jump and 10m Sprint*

Measurement	Mean ± SD	Units	95 % Confidence Interval		
			Average Measures	Lower Bound	Upper Bound
Peak Force	26.83 ± 5.29	Newtons per kg	0.983	0.954	0.986
RFD 100ms	2967.28 ± 1692.31	Newtons per second	0.619	0.160	0.828
RFD 200ms	2955.16 ± 1288.05	Newtons per second	0.634	0.213	0.833
RFD 300ms	2394.09 ± 973.78	Newtons per second	0.626	0.194	0.83
10m Sprint	2.18 ± 0.15	Seconds	0.987	0.958	0.955
CMJ	35.42 ± 7.42	Centimetres	0.993	0.974	0.998

Values are expressed as mean ± standard deviation (n = 26). Sample testing reliability measuresare presented as a two-way random interclass correlation coefficient (ICC). CMJ = countermovement vertical jump; RFD = rate of force development.

Table 3. *Correlation values for absolute and relative strength in BODYPUMP*[TM] *when correlated to performance measures for strength and power measurements in the isometric mid-thigh pull, countermovement jump and 10m Sprint*

Measurement	Total load	Load per kg
Peak Force	0.738	0.767
RFD 100ms	*0.285*	*0.214*
RFD 200ms	0.536	*0.474*
RFD 300ms	0.674	0.540
10m Sprint	0.712	0.490
CMJ	0.719	0.637
Rank	0.705	0.709
TSA	0.767	0.721

Total load (absolute strength or total maximal weight lifted during single session), Load per kg (relative strength or total maximal weight lifted during single session divided by body weight (kg)). All units for Pearson's correlations are arbitrary. Numbers given in italics illustrate a Pearson's correlation value of <0.5. CMJ = countermovement vertical jump; RFD = rate of force development.

Results

Data and reliability statistics are shown in Table 2.Statistically significant correlations were found between theabsolute load lifted in class and all parameters assessed apart from the RFD 100ms, (see Table 3 for correlation values). When considering ISO and dynamic measures, which did not account for body mass (i.e., absolute strength) and the relationship to total load in class the greatest correlation existed (r = 0.854). However, to strengthen this study and in order to eliminate the athletic advantage of absolute strength due to body mass additional calculations have been applied to show relative strength by dividing output parameters by body weight (BW). When the load lifted within the exercise class was corrected for body weight (load per kg) all previously statistically significant correlations remained.The strongest correlations observed were found between relative load lifted in class withisometric mid-thigh pull relative force (r = 0.767) and Total Score of Athleticism (TSA) (r = 0.721) as shown in both Table 3 and Figure 2.

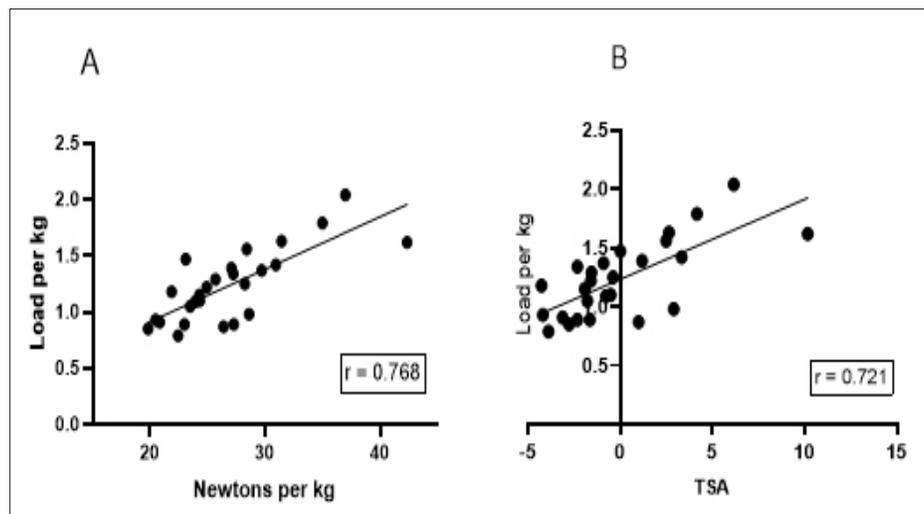**Fig 2.** *The overall effect of low resistance high volume training on strength and athleticism illustrated by correlation of load per kg on force output (A) and total score of athleticism (B) (r values for Pearson's correlations provided in text boxes aligned to each image, refer also Table 3)*

Discussion

To our knowledge, this is the first study that describes the transference of group-based fitness training to music toan overall assessment of athleticism, in this case the total score of athleticism (TSA)[15]. Specifically, key findingsfrom this research are the high correlation of BODYPUMP™ relative load to IMTP Peak force (*r*=.767). Peak force (PF) during the testing of the IMTP have been related to markers of athletic performance in sprint cycling, track sprinting, throwing, jumping and weightlifting [14,17–19]. The association of IMTP PFis maintained with performance in BODYPUMP™and the linkage to athleticism is further reinforced when looking at the relative load associated with the TSA.

Although it is documented that strength training promotes the greatest adaptation for strength gains it has also been shown that endurance training can increase strength gains in untrained individuals[20,21]

as well as resistance training providing endurance benefits [22].Key studies varying resistance training protocols through three modalities,high-resistance/ low-repetition (HRLR), medium-resistance/ medium-repetition (MRMR), and low-resistance/high-repetition (LRHR), showed comparable muscular outputs with respect to muscular hypertrophy and endurance[23,24]. The study by Stone and Coulter in femalesillustrated a 18.9% HRLR versus 11.6% LRHR increase in upper body strength and a 33% increase in Lower body HRLR compared to 25.1% LRHR,displaying that LRHR training produces significant strength gains across a nine week period[24].This pertains to this research as it presents the evidence that strength adaptations are achievable using LRHR as involved within BODYPUMP™ and would therefore explain the strong relationship (r =.767) found between IMTP 1RM and Total Load (kg)/Bodyweight (kg) (relative load).

The comparisons between resistance levels in training protocols with respect to optimum strength, endurance and hypertrophic gains are still far from optimised to date [1-3]position stands and recommendations are made based on, we propose, limited evidence to lift heavier weights. Here we discuss the state of evidence on the impact of load and how it, as a single variable, stimulates adaptations to take place and whether evidence for recommending heavier loads is available, well-defined, currently correctly interpreted or has been overlooked. Areas of discussion include electromyography amplitude, in vivo and in vitro methods of measuring hypertrophy, and motor schema and skill acquisition. The present piece clarifies to trainers and trainees the impact of these variables by discussing interpretation of synchronous and sequential motor unit recruitment and revisiting the size principle, poor agreement between whole-muscle cross-sectional area (CSA. With the more traditional measure of strength training being in terms of one repetition maximum (1RM) as a quantified maximuman alignment of this training format and athletic gains may require configuration into these commonly used maxima. A few studies have measured the level of self-selected weight mobilised during different movements in BODYPUMP™ in comparison to participants 1RM[7,8,10,11]and the health- and fitness industry offer several exercise programs with purpose to improve muscle strength and body composition. This randomised controlled trial aimed to compare 12 weeks (45–60 min, 3 sessions/weeks. These studies have shown a difference in weight selection between trained and untrained cohorts, illustrating a lower percentage of 1RM being selected by untrained individuals [7,8]we sought to quantify and compare the acute physiological responses within and between a BODYPUMP™ (BP. The data reported here was generated with participants who were trained and familiar with the BODYPUMP™ format so we can speculateparticipants self-selected loads of approximately 20–30% of their predicted maximum during BODYPUMP[TM7]we sought to quantify and compare the acute physiological responses within and between a BODYPUMP™ (BPand thussurmise that working with 20-30% 1RM will induced athletic changes. To isolate specifically the threshold limits of 1RM and athletic gains further studies fully documenting the weight self-selection of individual participants together with 1RM measurements would be required.

Whereas most correlations derived from this study were clear, total or relative load in class was not significantly correlated to isometric mid-thigh pull RFD at one of the three-time intervals taken (Table 3). This seems logical as the participants in this research have not been training in the conditions required to generate force quickly using neural drive to create a burst of muscle tension. As a potential result of the lack of neural drive, and associated training, the RFD at 100ms (r = 0.285 for total load; r = 0.214 for relative load) has a low significance. That said the reliability of this data set indicated a weakness (ICC = 0.614 [CI 0.160 – 0.828] refer Table 2) which may independently impair any associations.

In conclusion this research demonstrates that BODYPUMP™ does have athletic carryover for some components of fitness (strength, power and speed). This study has shown that the TSA is strongly correlated to lifting ability (r=0.721) within the training program. However, some study limitations require attention. Further sports specific testing would be required to determine if BODYPUMP™ can improve any specific and/or individualised sport performance. Also, it is not possible to ascertain if BODYPUMP™ improves sports performance based on thelow resistance high repetition components in equal balanceor is due to the enhanced motor-pattern, motor unit recruitment, reaction-time, reactive strength index (RSI) and/or time to stabilization (TTS). Further studies making these individualised measurements would be needed to isolate more specific muscular developmental details.

PRACTICAL APPLICATIONS

BODYPUMP™, when used as an individual's main exercise modality, provides sufficient stimulus for strength, power and speed improvements and as a result can be prescribed to individualsfor muscular strength and endurance gains.

BODYPUMP™ offers an alternative training mechanism to aid athletic/sports performance.

ACKNOWLEDGMENTS

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