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The role of Evidence Based Practice in Sports Therapy

Over the years, there has been a strong effort to incorporate clinical research into decision making (Straus et al. 2009). Adopting evidence based practice is essential for an industry which has historically shied away from scientific evidence, in favour of a belief system based on traditional values. The traditional philosophical approach to manual therapy is to encourage the body's inherent healing ability, to focus on personal responsibility for one's health, and educate patients in promoting healthy lifestyles (World Health organisation, 2010). While this traditional philosophical approach is still an important aspect of patient care, this view is fast becoming superseded by incorporating scientific evidence for therapeutic methods and modalities. To enhance patient experience and develop professional credibility, adopting evidence based practice is one key hurdle we must overcome.

Evidence based practice is a method in which healthcare professionals formulate clinical decisions, based on the best scientific evidence available (Sackett et al. 1996). There seems to be an overwhelming argument for the value of adopting evidence to inform clinical practice. Sports therapists, like other healthcare professionals, must begin to integrate evidence based practice. However despite its importance, the sports therapy profession seems reticent to implement evidence based practice in guiding clinical decisions.

There are numerous reports which highlight the barriers to implementing evidence based practice. For instance, Bennett et al. (2003) emphasised that practitioners have limited time to search, appraise and implement evidence. In addition, limited access to computers and journal articles, (Bennett et al. 2003; Curtin and Jaramazovic 2001), and also lack of practitioner self-motivation and interest (Curtin and Jaramazovic 2001), were other barriers to using evidence based practice. Scientific evidence should guide clinical decisions, however some authors suggest research does not always provide certainty about individual patients (Hebert et al. 2001), coupled with limited quantity and quality of evidence in specific clinical areas (Bennett et al. 2003; Hebert et al. 2001). It is also known that very little is known about the interventions we adopt in a clinical setting. In a recent issue of The Spine Journal on Evidence Informed Management of Chronic Low Back Pain listed over 200 treatments currently being offered to patients with low back pain (Haldeman and Dagenais 2008). Of these treatments, less than 10% have a reasonable body of scientific support.

This raises several key concerns. Firstly, the specificity of papers being produced should be guided by clinical questions from practitioners. Clinical research questions should be the reflection of the specific concerns of a patient population. Secondly, access and communication from practitioners needs to filter to academic researchers to ensure academic manuscripts are representative of clinical practice. Sports therapists need to develop their own specific body of knowledge, so we can move forward as a profession. It is plausible to argue that practitioners should be responsible for their own self directed learning and engage in evidence based practice. As a profession, we should not be satisfied with anecdotal, non-specific preaching from non-evidence based practitioners who may confuse clinical expertise with scientific fact.

An area of healthcare research which has become truly important is informed decision making. The need to communicate research evidence or its absence to patients is important to develop both therapists and patient decision making (Bronfort et al. 2010). It is accepted that manual therapy has been used for the athletic population for some time (Galloway 2004), and the proficiency of a therapist is developed over time. However, it can be argued that clinical expertise cannot be obtained by the therapist without adopting best available evidence. Clinical expertise is the proficiency and judgment that individual practitioners make about their patients welfare (Raina et al. 2004). The role of the 'science of common sense' preached by public figures in the manual therapy industry, from an academic view point is both dangerous and ignorant. Naylor (1995) echoes the danger of confusing educated guesswork and personal ignorance with genuine scientific validation.

This edition of the JST bridges the gap between evidence and practice. The appreciation of what is seen in clinical scenarios is represented by Workman, who presents a case study on 'Dry land training for Kayaking and its Implications on longevity and Performance'. Additionally, Fowler, analyses the role of psychology during shooting in university netballers. Research is also exhibited to help guide clinical decision making. For instance, Hong and colleagues present 'The Acute Effects of Whole Body Vibration on Rate of Force Development and Electromechanical Delay, which aims to explain the effects of whole body vibration on neuromuscular activation. Furthermore, research by Duncan and colleagues compare peak power prediction equations in adolescent female basketballers.

As this year draws to an end, I would like to take this opportunity to thank the Journal of Sport Therapy editorial team for their tireless work over the year in collecting, editing and publishing manuscripts. I would also like to extend my gratitude to colleagues at university College Birmingham, Coventry University and University of Wolverhampton, for their devoted support and enthusiasm for the Journal of Sports Therapy project. And to readers of, and contributors to, the Journal of Sports Therapy, for your growing support. We are sincerely grateful. We hope you enjoy this edition of the Journal of Sports Therapy and wish all our readers a merry Christmas, happy New-year and prosperous 2011.

Robert Di Leva
Editor Journal of Sports Therapy

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Randomised controlled study

Acute Effects of Whole Body Vibration on Rate of Force Development and Electromechanical Delay.

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KEY WORDS

Whole body vibration
Neurological adaptation
Rate of force development
Electromechanical delay
EMG

ABSTRACT

Background: The ability to generate rapid and powerful muscle contractions within a short period of time is an important factor for both enhancing sports performance and preventing injuries. Recently, whole-body vibration (WBV) has been introduced as a novel training method designed to produce neuromuscular improvement similar to that of power and strength training. However, to date there are only limited data on the acute effects of WBV on the neuromuscular system. Furthermore, there is little understanding about the responsiveness of the neuromuscular system to acute exposure WBV.

Research question: The present study examined the effect of acute WBV training on the rate of force development (RFD) and electromechanical delay (EMD) in the soleus muscle.

Type of study: Randomized controlled study.

Methods: Forty young individuals with no leg injuries were randomly assigned to an experimental or control group. The experimental group received acute WBV (3 bouts of 2 minutes). The control group adopted the same position (squat position) on the vibration platform for an equal time but received no vibration.

Results: The experimental (WBV) group demonstrated a significant group $\times$ time interaction for the rate of force development (RFD) and electromechanical delay (EMD) representing 15.6% (from 274Nm/sec to 323 Nm/sec) and 16% (from 23.42 ms to 19.3 ms) improvement.

Conclusions: It appears that acute WBV enhances RFD and EMD of the soleus muscle in young healthy subjects.

Introduction

Rate of force development (RFD) represents the ability to rapidly contract muscle and is closely related to an enhanced early neural activation of the trained muscle. Electromechanical delay (EMD), another important neuromuscular related variable, is the delay between the onset of electromyography (EMG) and the onset of mechanical response of the muscle. Increases in RFD and/or decreases in EMD can have important functional consequences as these allow greater and faster levels of muscle contraction for better sports performance and active stabilization of joints in injury-related situations.

Previous studies have shown that RFD and EMD can be improved by neuromuscular training designed to promote neural adaptation in the muscle (Gruber and Gollhofer 2004; Linford et al 2006). For example Gruber and Gollhofer (2004) reported that a 4-week sensorimotor training program had a significant impact on the rate of force development specifically in the early phase of muscle contraction. And Linford et al. (2006) showed that a 6-week neuromuscular training program significantly decreased electromechanical delay of the peroneus longus muscle in healthy subjects.

Recently, whole body vibration (WBV) training has become increasingly used in sports training and injury treatment settings as an efficient neuromuscular training tool. Some authors suggest WBV exercises can acutely enhance strength and power capabilities in untrained as well as trained individuals (Schuhfried et al 2005). For example, acute application of WBV applied for a total of 10 minutes was shown to increase leg extensor muscle power and countermovement jump height in elite athletes (Bosco et al 2009). Additionally WBV has been used in patients with neuromuscular deficit. A recent study by Tihanyi, Horvath and Fazekas (2007) with stroke patients showed 1 minute WBV treatment improved the patients' isometric and eccentric knee extension torque (Tihanyi, Horvath and Fazekas 2007).

Several mechanisms for these acute effects of WBV training have been suggested, including neural adaptation related to increased muscle activation caused by increased excitability input from muscle spindles exposed to a vibration (Abercromby et al 2007). It has been hypothesised that the enhanced muscle power observed following acute vibration occurs via potentiation of the neuromuscular system whereby stimulation of muscle spindles (Ia afferents) results in reflex activation of motor neurons with increased spatial recruitment (Komi 2000; Romaguere, Vedel and Pagni 1993). It has been also suggested that the increased level of neural drive following WBV training is closely related to increased muscle stiffness, which is known to contribute to shortening EMD (Komi 2000; Romaguere, Vedel and Pagni 1993).

Based on the theoretical mechanism of WBV proposed by researchers, it is likely that increased neural drive and muscle stiffness induced by WBV would reduce the rate of muscle shortening and therefore reduce the amount of time necessary to produce force or tension. However, to date it is not clear how such a short exposure to WBV can acutely enhance the rate of force development and electromechanical delay. The purpose of the present study was to investigate the acute effects of WBV on RFD and EMD of the soleus muscle in healthy subjects.

Methods

A total of 40 individuals (20 males, 20 females, mean age = 24.27 ± 5.97 yrs) with no history of lower leg injury were recruited through flyers posted on a university campus. Informed consent was obtained from each subject prior to participation in accordance with the university's Institutional Review Board. Subjects were sex stratified and randomly assigned to either of the treatment (WBV) or control (No-WBV) group.

Subjects in the WBV group stood, with knees flexed to approximately 20° , on the vibration platform (TurboSonic™ Seoul, Republic of Korea) (Figure 1). The experimental param-

eters for the WBV device were a frequency of 20 Hz and 5 mm amplitude during each of three 2-minute periods. Each training session lasted 10 min. The No-WBV group performed the same static semi-squatting position on the floor.

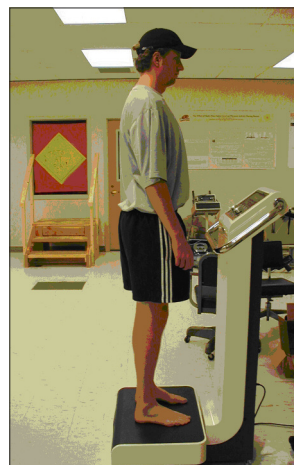


Figure 1: Vibration Treatment

All subjects (WBV and No-WBV) were tested before and after a set of vibration exposures on the testing days. The outcome measures were: 1) the rate of force development, 2) electromechanical delay. Both measurements were recorded in the soleus muscle. Outcome measures were calculated from the same trials. And all testing procedures were performed on the dominant leg.

For all subjects, RFD and EMD were obtained on the dominant ankle using an isokinetic dynamometer (Biodex System 3 Pro, Biodex Medical Systems Shirley, NY). The subjects sat on the testing chair of the dynamometer and the leg was secured with body straps (Figure 2), while the hip and the knee joints are flexed at 100° . All subjects were instructed to "plantar flex the ankle as hard and as fast as possible" for the testing. Three trials were performed with 1-minute rest between each trial.

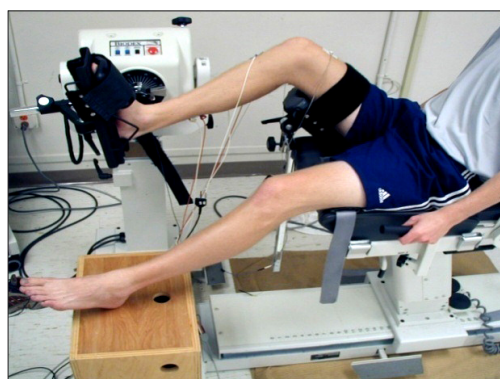


Figure 2: RFD and EMD testing position

The force signal and the EMG signals were synchronously sampled at 2000 Hz. The raw unfiltered signals were analogue-to-digital converted (Acqknowledge Software v.3.9.1, Biopac Systems, Goleta, CA) and stored on a PC. During the later process of analysis, the force signals and EMD were digitally high-pass filtered by using a fourth-order, zero lag Butterworth filter with a 50 Hz cut off. Onset of force and EMG was determined by the cumulative sum technique (Cholz and Millford 1995). Maximal RFD was calculated from the individual maximal isometric force development record. RFDmax was defined as the maximal slope of the force time curve ($\Delta\text{force}/\Delta\text{time}$) (Aagaard et al 2002). EMD was defined as the time interval between the onset of EMG and the onset of the force applied to the footplate (Muraoka et al 2004; Zhou et al 1996).

All statistical analyses were performed using the SPSS 15 software (SPSS, Inc., Chicago, IL). Initially a 1-way ANOVA was applied to the baseline data to determine if differences between the groups (WBV, No-WBV) existed. Next, a 2 x 2 (group by test) mixed design ANOVA was applied to the RFD and EMD data. Descriptive data are reported as mean $\pm$ standard deviation (SD).

Results

The two groups were equivalent at baseline (Table 1). The 2 x 2 ANOVA showed a significant group $\times$ test interaction for RFD ($p=.003$). However, the evaluation of the interaction revealed that the differences between the means in the vibration group and the control group were not statistically significant [pre ($p=.329$) and post ($p=.876$)] (Table 2). After acute WBV exposure, RFD increased by about 15.6% (from 274.13 N/sec to 323.03 N/sec) in the WBV group (Figure 3)

	WBV (n=20)	No-WBV (n=20)	
	Pre	Pre	<i>P</i>
RFD (N/sec)	274.13 $\pm$ 137.77	318.41 $\pm$ 145.42	<i>P</i> =.329
EMD (ms)	23.42 $\pm$ 7.54	21.25 $\pm$ 7.63	<i>P</i> =.371

Table 1: Comparison of group differences for the baseline values of EMD and RFD

	WBV (n=20)		No-WBV (n=20)	
	Pre	Post	Pre	Post
RFD (Nm/sec)	274.13 $\pm$ 137.77	323.02 $\pm$ 161.98	318.41 $\pm$ 145.42	315.54 $\pm$ 137.99
EMD (ms)	23.42 $\pm$ 7.54	19.3 $\pm$ 8.08	21.25 $\pm$ 7.63	21.11 $\pm$ 6.49

Table 2: The mean and standard deviation of the neuromuscular parameters

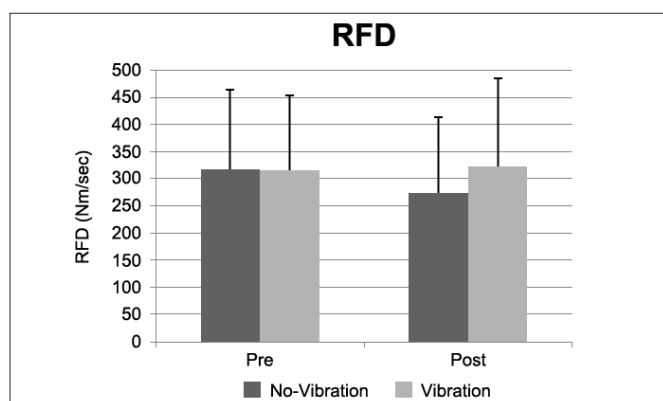


Figure 3: Mean and standard deviation (SD) of the RFD before and after three bouts of 2 minutes WBV training in the WBV group and the No-Vibration group. In WBV group, there is a 15.6% increase between pre and post-test.

The 2 x 2 ANOVA showed a significant group $\times$ time interaction for EMD ($p=.002$). However, the evaluation of the interaction revealed no significant differences between the means in the vibration group and the control group at either testing time [pre ($p=.371$) and post ($p=.438$)]. EMD decreased by about 16% (from 23.42 ms to 19.3 ms) in the WBV group (Figure 4).

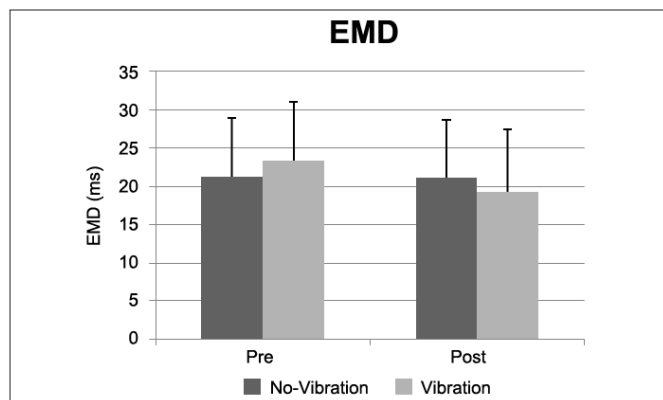


Figure 4: Mean and standard deviation (SD) of the EMD before and after three bouts of 2 minutes WBV training in the WBV group and the No-WBV group. EMD decreased by about 16% (from 23.42 ms to 19.3 ms) in the WBV group.

Discussion

The aim of this study was to examine changes in the neuromuscular properties of soleus muscle in young healthy individuals after three bouts of 2-minutes WBV. To assess neuromuscular function of the soleus, rate of force development (RFD) and electromechanical delay (EMD) were tested. Our results indicated that the WBV protocol used in the present study increased RFD and decreased EMD during isometric contractions; no changes were observed in the control group.

Increased rate of force development (RFD)

The RFD has functional significance in fast and forceful muscle contraction and any increase in RFD is important as it allows reaching a higher level of muscle force in the early phase of muscle contraction (Aagaard et al 2002).

The findings of this study demonstrated that following three bouts of 2 minutes WBV, maximal rate of force development (RFD) increased by about 15.6% (from 274 N/sec to 323 N/sec) in the WBV group whereas maximum RFD remained unchanged (318 N/sec to 315 N/sec after 4 weeks of study period) in the control group. In our study, RFD is defined as the slope in the force time curve ($\Delta\text{force}/\Delta\text{time}$). (Gruber and Gollhofer 2004)

It has been documented that the effects of WBV on functional muscular performance is similar to the effects of resistance training (Torvinen et al 2002a; Torvinen et al 2002b) and that the first adaptation mechanism of a skeletal muscle to resistance training is neural (Torvinen et al 2002a; Torvinen et al 2002b). Previous studies suggested that WBV improved power (Bosco et al 2009; Bosco et al 2000) and force generating capacity in lower limbs (Bosco et al 2009; Torvinen et al 2002a; Torvinen et al 2002b). Although changes in RFD after acute WBV in the present study may be due to neural adaptation, to date since there are few data available on the effects of acute WBV on the contractile rate of force development or the exact mechanism by which acute exposure to WBV can enhance neuromuscular activation or muscular performance.

During a whole body vibration, skeletal muscles undergo small changes in muscle length, most likely because mechanical vibration is able to induce a tonic excitatory influence on the muscles (Seidel 1988). It has been shown that vibration elicits tonic vibration reflex (TVR) including activation of muscle spindles, mediation of the neural signals by Ia afferents (Hagbarth et al 1976). TVR is also known to affect the subjects' ability to generate high firing rates in high-threshold motor units (Bongiovanni, Hagbarth and Stjernberg 1976). In addition, it has been demonstrated that the recruitment threshold of the motor units during WBV are expected to be lower compared with voluntary contractions, possibly resulting in a more rapid activation (Romaiguere, Vedel and Pagni 1993; Bongiovanni and Hagbarth 1990). From these findings, we infer that the RFD changes in the present study may be due to the effects of tonic vibration reflex on the recruitment threshold of motor units.

As a contributing factor, the increase in the sensitivity of the stretch reflex is known to be related to the acute enhancement of neuromuscular performance after WBV (Cardinale

and Pope 2003). Considering that attenuation of stretch reflex is a common finding after demanding exercise, the maintained or increased stretch reflex amplitude observed after WBV seems most likely due to an enhanced central motor excitability, particularly with respect to the fast twitch fibres and motor units (Rittweger, Mutschelknauss and Felsenberg 2003). Shinohara et al. (2005) demonstrated a significant increase in stretch reflex amplitude and motor unit discharge rate after prolonged muscle vibration, and indicated that the increased stretch reflex depends on the sensitivity of the muscle spindles, which is determined by the level of gamma motor neuron activity (Shinohara et al 2005). Although the stretch reflex was not assessed in the present study, since maximal force is closely related to the RFD, enhancement of stretch reflex can be considered as a possible explanation for the changes in RFD observed in our study.

Among many different physiological factors thought to contribute to the changes in RFD, the spinal adaptation caused by training has been discussed as a possible mechanism for enhancing RFD. Gruber and Gollhofer (2004) suggested that increased frequency, earlier recruitment as well as improved synchronization could be related to an excitatory modulation of the spinal motor neuron pool. Holtermann et al. (2007) reported that the modulation of motor unit recruitment and discharge rate with training involve an enhanced synaptic excitatory input to the motor neuron pool or increased motor neuron excitability (Holtermann et al 2007). It has been suggested that the contributing intrinsic neural mechanism for the improvement in muscle function after WBV training might be due to vibration induced presynaptic inhibition (Romaiguere, Vedel and Pagni 1993; Bongiovanni and Hagbarth 1990; Rittweger, Beller and Felsenburg 2000). This could be another important neural mechanism for the RFD changes in the present study. Capaday and Stein (1987) suggested that the neural modulation of presynaptic inhibition pathways affects the recruitment of motor units for voluntary movements (Capaday and Stein 1987). In addition, Kukulka and Calmann (1981) reported that the enhanced excitatory synaptic input or motor neuron excitability with training causes high-threshold motor units to be recruited earlier in a maximal voluntary contraction (MVC) increasing RFD, whereas recruitment of additional motor units ends before maximal tension (Kukulka and Calmann 1981). From the above findings, we suggest that the change in RFD after acute WBV observed in the present study may have occurred by neural modulation potentially involving alterations in recruitment threshold, stretch reflex, or presynaptic inhibition (Aagaard et al 2002).

Although the present study did not include the measures of acute change in presynaptic inhibition after WBV training, it has been suggested that the contributing intrinsic neural

mechanism for the improvement in muscle function after WBV training might be due to vibration induced presynaptic inhibition (Romaiguere, Vedel and Pagni 1993; Bongiovanni and Hagbarth 1990; Rittweger, Beller and Felsenburg 2000). Furthermore, the neural modulation of presynaptic inhibition pathways is known to affect the recruitment of motor units for voluntary movements (Capaday and Stein 1987). Further research is needed to test the hypothesis that WBV exercise interacts with spinal reflex loops and possibly influences these pathways, and examine how this spinal mechanism is related to the improvement in muscle function caused by WBV.

A shortened electromechanical delay with WBV

In this study electromechanical delay was defined as the lag time between the beginning of the soleus muscle activation and the beginning of the plantar flexion torque.

To identify possible explanations for the changes observed in the present study, it is important to isolate factors that influence EMD including the maximal voluntary contraction force, rate of force development, muscle fibre types, muscle spindle sensitivity and stiffness of series elastic components (SEC) of the muscle.

Regarding the change in EMD observed in the study, there are several possible mechanisms that may explain how acute WBV can increase the sensitivity of muscle spindles and muscle stiffness. The primary endings of muscle spindles are more sensitive to vibration than are the secondary endings and golgi tendon organs. Vibration is perceived not only by neuromuscular spindles, but also by the skin, the joints, and secondary endings (Torvinen et al 2002a; Torvinen et al 2002b). Consequently, during application of WBV these sensory structures likely facilitate the gamma system and enhance the sensitivity of the primary endings of the muscle spindles (Cardinale and Bosco 2003). It has been shown that the tonic vibration reflex induces a sensitization of the muscle spindles and increases facilitation of the reflex action on the motor neuron pool (Romaiguere, Vedel and Pagni 1993).

Cardinale and Bosco (2003) reported that when muscles are vibrated, muscle spindle sensitivity and muscle stiffness increase to dampen the vibration. WBV causes fast joint rotation and muscle stretching which is likely to increase muscle stiffness through activation of both alpha and gamma sensory motor neuron (Shinohara et al 2005). To better understand the mechanism of WBV on muscle stiffness, the response of musculotendinous units to WBV has been examined (Nigg and Wakening 1985). Nigg and Wakening (1985) demonstrated that impact forces during running produce vibration, which are transmitted to the body at a frequency between 10 and 20 Hz. The study found that the soft tissues

of the lower limbs damp the vibrations coming from heel contact, changing their stiffness. The adjustment of the stiffness of the lower limbs is not only based on the sensory receptors in muscles, but also in the joints, ligaments, and in the skin (Nigg and Wakening 1985). This mechanism called "muscle tuning," may be the adaptive response to the acute application of WBV, resulting in the changes in EMD.

Another factor that may have contributed to the EMD changes in the present study is based on the mechanism that the vibration effect would be larger in the posture in which the receptor-bearing muscle is more pre-activated. Roelants et al. (2006) have noted that elongated muscles or an increased muscle length or increased degree of pre-activation seemed to be most affected by vibration (Roelants et al 2006). In addition, Burke et al. (1976) suggested that even a small increase in pre-activation may lead to increased muscle spindle sensitivity because of alpha-gamma co-activation which is known to increase the muscle stiffness (Burke et al 1976).

The findings of this study showed a substantial decrease in electromechanical delay after acute WBV. However, as no studies have yet investigated the effects of acute WBV on EMD of the soleus muscle in healthy subjects, the exact mechanism responsible for this change remains unknown. Future studies should investigate how EMD is affected by the physiological factors suggested to contribute to the changes in electromechanical response of the muscle (muscle stiffness, muscle spindle sensitivity, muscle fibre types, muscle length, muscle pre-activation, etc.).

Conclusion

The present study clarifies the impact of whole body vibration training on neuromuscular adaptation. Acute treatment with whole body vibration (WBV) so far has been shown to elicit adaptive changes primarily in the muscle function. The present study indicated that acute WBV positively influences the speed of neuromuscular activation, which can be beneficial for the explosive type of muscular activation. Further research is needed to investigate the parameters of vibration exercise duration, frequency, amplitude, and load that are optimum to evoke enhanced neuromuscular function in various populations including young adults, athletes, elderly subjects and clinical patients.

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Original Research

Comparisons between peak power prediction equations in adolescent female basketballers

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KEY WORDS

Vertical Jump
Counter-Movement Jump
Force Platform

ABSTRACT

The aim of this study was to compare previously validated prediction equations for estimating peak power from vertical jumping with actual peak power determined via force platform analysis. Eighteen elite junior female basketball players (age = $16.5 \pm .5$ years) performed a series of counter movement jumps (CMJ) on a portable force platform. Actual peak power (PP_{actual}) and CMJ height were determined from force platform data. Peak power was also estimated (PP_{est}) using four commonly used regression equations. Significant relationships were evident between PP_{actual} and PP_{est} as estimated by the Harman et al, Sayers-SJ Sayers-CMJ and Canavan and Vescovi equations (all $P < 0.01$ or better). There were significant differences between PP_{actual} and PP_{est} using the Harman et al ($P < 0.02$) and Sayers-SJ ($P < 0.01$) equations but not the Sayers-CMJ and Canavan and Vescovi equations ($P > 0.05$). Typical error was also lowest (8%) for the Sayers-CMJ equation. The results of this study suggest that there are differences between peak power directly determined from a force platform and peak power estimated using regression equations in this sample of elite, jump-based athletes. As typical error was lowest and there were no differences between actual and estimated peak power for the Sayers-CMJ equation, scientists practitioners may be best placed using this equation when estimating CMJ peak power in field settings with female jump-based athletes.

Introduction

In a number of sports, the ability to generate power is a key element to success (Kraemer et al., 2003) and the assessment of power is important in development of sport-specific assessments to gauge training and/or rehabilitation programmes (Kalinski et al., 2002). The force platform has been widely used to assess power within laboratory settings (Linthorne, 2001; Canavan and Vescovi, 2004) and while this method provides a precise, direct measurement of power, its use has been restricted with athletic groups due its cost and inaccessibility outside of the laboratory. As a result, vertical jump height has been widely used as a proxy in the assessment of power.

A number of prediction equations have been developed to estimate peak and average power from jump height. Research (Canavan and Vescovi, 2004) has however, questioned the validity of these equations. Studies (Harman et al., 1991; Sayers et al., 1999) used separate tests to determine vertical jump height and peak power instead of pairing values from the same jump and one study (Sayers et al., 1999)

included a heterogeneous sample of men and women from varied athletic backgrounds. As differences exist in jump technique and coordination between genders and between athletic/non-athletic groups (Hertogh and Hue, 2002; Kalinski et al., 2002), it could be argued that a more homogenous sample was needed to fully validate these equations.

In response to these criticisms, Canavan and Vescovi (2004) compared actual peak power (PP_{actual}) measured using a force platform with peak power estimations (PP_{est}) using the Harman and Sayers equations in a group of 20 recreationally trained females. They reported that all peak power prediction equations were significantly related to PP_{actual} but only the Harman et al., prediction was not significantly different to PP_{actual} . In addition, Canavan and Vescovi (2004) performed a regression analysis and produced a new prediction equation to estimate peak power from vertical jump height. However, their regression equation needs to be cross validated with larger or different samples and in particular, elite athletes (Canavan and Vescovi, 2004).

More recently, Duncan et al. (2008) compared peak power prediction equations in male adolescent basketballers. They reported that, in all cases, peak power was underestimated by the prediction equations used in their study. Surprisingly, this study compared the Canavan and Vescovi regression equation, originally developed on a female population, with male basketballers. They also suggested that, due to sport specificity of movement patterns and power output, future research should evaluate peak power prediction equations in a range of athletic groups. The aim of this study was to compare PP_{actual} with PP_{est} in a group of elite female basketball players. The study hypothesized that there would be significant differences between actual peak power and peak power estimated from prediction equations.

Methods

Participants

Eighteen elite junior female basketball players (age = $16.5 \pm .5$ years, Mass = 74.2 ± 11.8 kg, Height = 181.8 ± 8.1 cm) volunteered to participate in this study following informed consent and institutional ethical approval. Participants were all members of the England U18 women's basketball squad and all were playing at national/international level.

Procedures

PP_{actual} and maximal CMJ height was assessed using a Quattro Jump Portable Force Platform System (Kistler, Amherst, NY) at a sampling rate of 500 Hz. Participants were instructed to begin from a standing position and perform a crouching action immediately followed by a jump for maximal height. Jump technique was demonstrated to each participant and was followed by two submaximal attempts. Three maximal jumps, separated by ample rest (>5 min), were then completed. Test-retest reliability was indicated by a high correlation ($r = .98$) for vertical jump height. This was confirmed with 95% limits of agreement value of 2%.

Statistical Analysis

All statistical analysis was performed with SPSS version 13.0 (SPSS Inc, Chicago, IL). Pearson product moment correlations were used to determine the relationship between PP_{actual} and PP_{est} using the Harman et al (1991), Sayers Squat JUMP (SJ) and Counter Movement Jump (CMJ), (1999) and Canavan and Vescovi (2004) prediction equations. Repeated measures ANOVA was used to examine any differences between PP_{est} and PP_{actual} . Typical error as a coefficient of variation (%) between PP_{actual} and PP_{est} for each prediction equation was also calculated in accordance with recommendations for assessing reliability of measures in sport and exercise performance (Hopkins, 2000).

Results

Significant relationships were evident between PP_{actual} and PP_{est} as estimated by the Harman et al ($r = .682$, $P = .003$), Sayers-SJ ($r = .684$, $P = .002$), Sayers-CMJ ($r = .724$, $P = .001$) and Canavan and Vescovi ($r = .642$, $P = .006$) equations. Repeated measures ANOVA also revealed that there were significant differences between PP_{actual} and PP_{est} ($F_{4, 64} = 16.371$, $P = 0.0001$). Bonferroni post-hoc pairwise comparisons revealed that PP_{actual} was significantly different to the Harman et al (Mean Diff = -517.7 , $P = .027$) and Sayers-SJ (Mean Diff = -713.2 , $P = .001$) equations but was not significantly different to the Canavan and Vescovi (Mean Diff = -369.4 , $P = >0.05$) or Sayers-CMJ (Mean Diff = -223.6 , $P >0.05$) equations. Typical error, expressed as a coefficient of variation was lowest for the Sayers-CMJ equation (8%), followed by the Harman et al (10.6%), Canavan and Vescovi (11%) and Sayers-SJ (11.2%) equations. Mean $\pm$ S.D. of PP_{actual} and PP_{est} are presented in Figure 1.

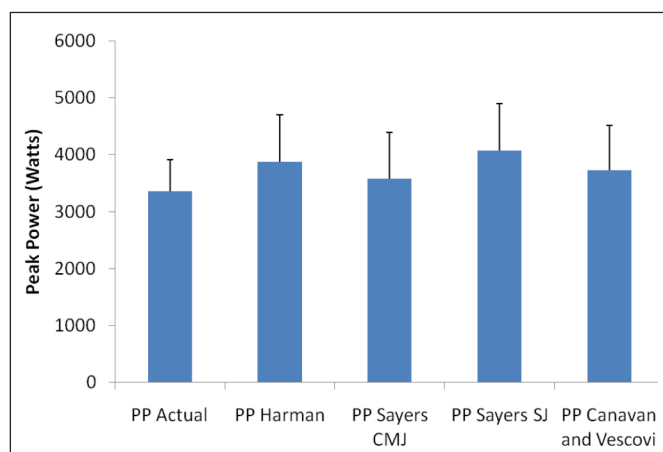


Figure 1: Mean $\pm$ S.D. of PP_{actual} and PP_{est}

Discussion

Results from the current study indicate that all regression equations previously used to estimate peak power from vertical jump height over predict PP_{actual} in female adolescent basketball players. The significant differences between PP_{actual} and PP_{est} in the current study therefore, support prior research (Canavan and Vescovi, 2004; Duncan et al., 2008). In their study, Canavan and Vescovi reported that peak power equations tended to overestimate PP_{actual} in college aged females. They also reported that the Harman et al. equation alongside their own regression formula provided the most precise estimate of PP_{actual} . In respect to the present study, the Sayers-CMJ equation appears to offer the most precise estimation of PP_{actual} in elite junior female basketball players. This is in agreement with research examining peak power predic-

tion equations in elite junior male basketballers (Duncan et al., 2008). However, in the study by Duncan et al (2008) PP_{est} was under estimated compared to PP_{actual} .

The discrepancy between the results of the current study and prior research can be attributed to a number of factors. Firstly, prior prediction equations (Harman et al, 1991; Sayers et al., 1999) used the jump and reach test to assess vertical jump height. Within this test, participants place a mark on a wall with their fingers at the top of their jump. This methodology is problematic as the contribution of trunk bend and shoulder elevation may not precisely measure the change in centre of mass when jumping. Similarly, comparison of PP_{actual} and PP_{est} from the same jump, as is the case in the current study, has been recommended (Duncan et al., 2008) and offers a more valid method to determine precision of peak power regression equations, especially in jump-based athletes.

Differences between the present study and the findings of Canavan and Vescovi (2004) may also be due to participant characteristics. In their study female students were used whereas the current study used trained female jump-based athletes. In the case of improving or tracking sports performance, the results from the current study agree with assertions previously made (Hertogh and Hue, 2002; Duncan et al., 2008) that development of regression equations in more homogenous samples may be needed when dealing with sport-specific performance and testing needs.

Despite this, the similarity between PP_{est} using the Sayers-CMJ equation and PP_{actual} is not unexpected as the current study employed a counter movement jump as did the Sayers-CMJ equation, whereas other equations (e.g., Harman et al, Sayers-SJ) are based on a squat jump. Jump height is typically greater with a counter movement compared to a squat jump as more work is generated in the preparatory counter movement (Bobbert et al., 1996).

Conclusion

Previously validated regression equations used to estimate peak power from vertical jump height in the current study over predicted actual peak power in female adolescent basketball players. Accurate estimation of peak power is essential when setting and evaluating strength and conditioning programs for basketball. Therefore, future work which attempts to validate an equation to estimate peak power in a comparable sample is needed. There is also a need for researchers to consider developing sport-specific, biologically sound, regression equations to predict peak power across athletic groups in general

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Original research

The Effects of Psychological Skills Training on Shooting Accuracy in University Netball Players.

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KEY WORDS

Imagery
Netball
Systematic practice
Practice and competition.

ABSTRACT

Objective: To analyse how Psychological skills training, specifically Imagery, affects shooting accuracy in University Netball Players.

Hypotheses: The scores of all the participants will increase after the imagery intervention has been introduced.

Design: A comparison of goals scored before and after the imagery intervention. Setting: All participants took part in a two sessions with and without the intervention.

Participants: Six netballers were selected from University College Birmingham. Intervention: Imagery.

Main outcome measures: Included mean averages of before and after intervention and a t-test to show the significance of the findings. Also correlation co-efficiencies were calculated for the questions asked within the questionnaire.

Results: It was found that on average scores before the intervention were better than after the intervention; however the t-test highlighted similarities between the two players that scored better after the intervention.

Conclusions: It was concluded that there should be a systematic practice of imagery within a practice setting before the use in a competition setting. It was also concluded that skill level was not a contributing factor to the effect of imagery. It is recommended that due to the small sample size further research should be conducted.

Introduction

With athletes increasingly wanting to gain an advantage to succeed many psychological techniques have been developed to provide them with this winning edge, one being mental imagery. Mental imagery has been described by Moran (2004, p.125) as "...an internal representation that gives rise to the experience of perception in the absence of the appropriate sensory input."

The use of imagery within sport has been established to enhance both cognitive and motivation purposes for the athlete. Furthermore scholars have also measured the impact of imagery on the neuromuscular system with the findings suggesting that imagining a specific task can activate the specific muscle needed (Sheikh and Korn, 1994). Many academics

have reported on the use of imagery on sport and the effects of performance, Martin et al (1999) proposed that over 200 studies have examined the association between imagery and performance in sport. Many of these studies focus on collegiate level athletes with a large focus upon golfers (Beauchamp et al, 2002; Gregg & Hall, 2006; Short et al, 2005; Taylor and Shaw, 2002). Although numerous academics focus on the effects of confidence and self-efficacy levels upon imagery use, very little focus has been established within a team sport environment.

Post et al (2010) found that existing research and experimental evidence suggests that the use of imagery can enhance performance through the competition related thoughts and

emotions of athletes. Much of the research that has gained the experimental evidence has been based on Paivio's (1985) analytical framework. This again shares little evidence in the team sport environment particularly surrounding the sport of netball, therefore this study will investigate the effects of imagery on netball players. Making particular reference to the types of imagery used, standard of level of players, frequency use, practice and competition setting, a team sport and how imagery effects these within netball shooters.

Methods

Design

Each participant will be asked to fill out a consent form which explains the details of the intervention. This is will explain that the participants can ask to leave the intervention at any stage. Following the investigation each participant will be asked to complete a questionnaire which will aim to gather as much information from how each participant felt and responded to the imagery intervention.

Participants

From a total of 30 netballers at University College Birmingham, 6 were selected to participate as all had previous shooting experience. The 6 participants were of varying ability.

Procedures

The procedure consisted of two separate experiments on two different days, the first without the intervention and the second including the imagery speech. The imagery script was adapted from Williams (2010), to be suitable for netball shooting players. Before the process of the experiment was undertaken each participant was asked to read and complete a consent form to ensure they understood their individual rights, this can be found in Appendix B.

Once the statement in appendix C had been read to the 6 participants, they were taken on the court. Set up within the semi-circle was a goal post; with four cones around the semi-circle each 2.4 metres away from the post. Each participant was allowed 3 practice shots from each marker to reduce the risk of practice effects. Taylor and Shaw (2002, p. 609) defended the use of practice shots as they wrote, "The main aim of this practice was to familiarise the participants with the task and minimise any practice effects."

Next, each participant was randomly allocated a number of either 1 or 2 and asked to stand behind one of the four markers. They were reminded to continue focusing on the imagery task that was performed earlier. All the 1s were then told to take two shots at goal, in turn. Once this was finished the 2s were told to repeat this step. However when told to move to the next cone placed around the circle the 2s were told they

had to shoot first. This was proposed by the author to reduce the effects of anxiety by the same player having to always go first. These two processes were repeated for the final two cones. Once all the shots had been taken and scores recorded by the author, each participant was asked to answer the questionnaire detailed in appendix A.

By conducting the questionnaires face to face, an increase in the return rate to one hundred per cent will be achieved. Although by conducting the questionnaire after they have performed may reduce the memory of the participants, it is supported by Beauchamp et al. (2002, p.700), as they also conducted a questionnaire as soon after completion as possible so not to disrupt the participants focus, whilst they also concluded that completing the questionnaires beforehand was; "...deemed unethical to burden them with questionnaire completion at that time."

Statistical analyses

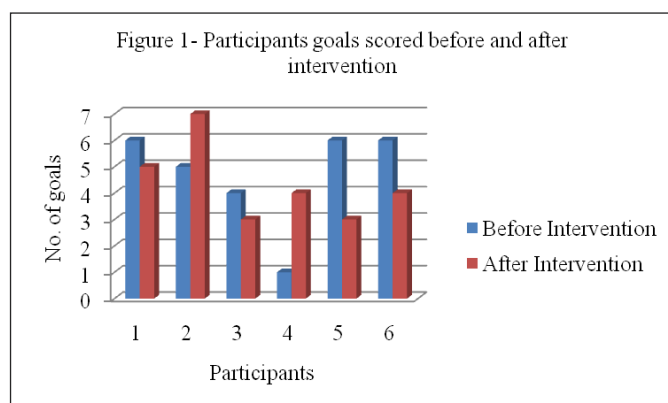
Firstly, a comparison of the scores for each of the participants was conducted, identifying the scores without imagery intervention compared to that of when imagery was included. This allowed the author to analyse if the imagery intervention had an effect on shooting scores and also if it effected the varying participant abilities differently. This was accurately tabulated to aid comparison and allowed for a mean average to be calculated for before and after the intervention. This indicated to the author in a mathematical format whether the imagery intervention improved shooting accuracy. A further analytical tool of using a t-test was incorporated by using the dependant t-test. This was used as Thomas et al. (2005) clarified that when comparing the same participants the dependant format should be used. The t-test allowed for a statistical significant conclusion to be drawn on whether the means of the two groups of before and after the intervention show significant findings or not (Babbie 2009). The results of the t-test refers to a probability value at a 5% significance level therefore if the result is smaller than 0.05 there is significance of the result obtained, however if the result is higher than 0.05 there is no significance in the result (Anderson et al, 2009).

Following the completion of the questionnaires each of the participant's responses was tabulated which also included information from the consent forms. Correlation co-efficiencies were calculated to evaluate correlation between results and performance. This allowed the author to draw conclusions on whether the way the respondents answered the questions related to why they performed either better or worse after the imagery intervention. The correlation co-efficiency results have a linear relationship when the result indicates an answer between zero and -1 and no linear relationship when the answer is between zero and +1 (Cohen et al, 2003).

Results

Figure 1 shows how many goals each respondent scored before and after the imagery intervention. From the graph it can be seen that only two respondents scored better after the intervention. Participant 2 scored two more goals after the intervention with participant 4's scores being at a higher increase of a difference of three. The graph also indicates that in one instance a player scored half the amount after the imagery intervention, whereby the remaining three varied by a difference of one to two

Figure 1: Participants goals scored before and after intervention



From calculating the goals scored by each respondent the researcher was able to calculate the mean average of goals scored before and after the intervention. The mean average before imagery was calculated at 4.6667, and again for after imagery being 4.3333. Although there is only a difference of 0.3334 on average, this reaffirms that on average the respondents scored better before the imagery script was introduced.

From concluding the mean averages it was then possible to conduct a statistical t-test analysis to discover the significance of the result. The t-test result was calculated at 0.7484, as this number is greater than 0.05 it shows that there is no significance between the two types of data collected.

Following each participant completing the questionnaires it was possible for the author to tabulate the results (Appendix D). Figure 2 below shows the three positive correlation co-efficiencies between the questions and the improvement after imagery scores. The two main respondents that the author is to concentrate on are participants 2 and 4 due to having positive scores after the imagery intervention whilst having answered similarly on the three questions shown in Figure 2. The individual questions measured how vividly they heard the sounds (Q2), how clearly they felt their emotions of the

situation (Q4) and that they both viewed themselves when using the imagery from outside their bodies (Q6).

Participants	Q2	Q4	Q6	Improvement after Imagery
1	1	1	1	-1
2	3	5	3	2
3	1	3	1	-1
4	4	5	3	3
5	1	3	2	-3
6	1	1	1	-2
Correlations	0.9439	0.7651	0.7540	

Within Appendix D it can be analysed that the lowest of the correlations is that of question 1; how clearly you saw yourself scoring the goal, being calculated at 0.0379. Although that the majority of the respondents rated quite highly for this question, none of them rated higher than a 4.

Discussion

Although types of imagery were not spoken about directly within the questionnaire a pertinent few questions can be related to these. Question 4 asked how well the respondents felt their emotions of the situation, which can be directly linked to Motivational General Arousal (MG-A) as Martin et al. (1999) described this as imagery of somatic and emotional experiences.

Participants 2 and 4 both scored the highest on this question by rating a 5. The results of the co-efficiency correlations were strong as they were calculated at 0.7651 (Appendix D). Callow and Hardy (2001) found a similar finding in that less confident players used more MG-A imagery than more confident players. If we were to assume that the more confident players were more elite due to being more autonomous and vice versa then this would indicate why the results in this study were gained. Question 6 can also be interlinked with Paivio's analytical framework (Paivio, 1985) to that of Cognitive General imagery, as it asked the respondents to rate how well they saw themselves executing a shot at goal. Participants 2 and 4 again scored similarly and again the highest scores compared to the other players, by rating a 3. If the author was to follow the same trend in that the athletes selected did not have significant levels of expertise then the results obtained refute the literature. As many authors agree

that the more elite an athlete is the more Cognitive General (CG) imagery they should be acquiring.

When analysing the skill level of the participants it was apparent that there were two definite levels, players that had played at a level of University and players that had played at a higher level of representing their County. The results show that for this particular study there is no relationship between skill level and the effectiveness of imagery. As particularly from the two players that scored more goals after the intervention differed in skill level, as participant 4 had played at county level and participant 2 had not. However this result can support the work of Short et al. (2005), whereby it should not be the skill level that is considered the mediating affect upon the imagery ability but how efficacious an athlete is about using it. An explanation as to why the imagery intervention may not have been effective for those that had not used it before is that they did not have strong imagery abilities and it is considered by Short et al. (2005) that imagery is not an effective performance enhancing technique for this type of athlete. It has further been suggested that by building an athletes' efficacy in using imagery it may enhance the frequency of use by an athlete that in turn improves the athlete's imagery abilities. However the results from this study refute the literature surrounding the effects of skill level upon imagery ability.

As most research concluded that the more elite athletes utilise the benefits of imagery at an increased rate compared to their lower level counterparts, this could explain why participant 4 scored slightly more than participant 2 as she had played at a more elite level. Cumming and Hall (2002) concluded that lower level athletes do not respect the importance and impact that imagery can have on enhancing an athlete's performance. Furthermore if the athletes had more experience and had spent more time learning the skills of netball to become a more elite player then this would allow more time for the athletes to respect the importance of imagery in improving their performance (Gregg and Hall, 2006).

The results indicate that half the respondents have previously used imagery throughout their netball career and half had not. From the two prevalent netballer's participant 4 had used imagery previously and participant 2 had not. For this particular result the findings cooperate with previous research as it is concluded that the more elite an athlete is the more frequently imagery is used (Taylor and Shaw, 2002). Gregg and Hall (2006, p.967) explain that "...imagery is a skill that improves with practice", which further explains why when comparing the netballers that had used imagery previously to those that had not, scored slightly better. Therefore by referring to this, would the results be represented differently if a systematic practice was introduced over a period of time? This would then ensure that all athletes had previously

used imagery therefore understanding the benefits and as Short et al. (2005) elucidated that by practicing imagery it develops, maintains and regains the athletes' efficacy beliefs.

A possible cause of why the results did not show a strong correlation or a positive t-test result is according to literature, imagery has a more effective outcome on competition than practice. As the primary research in this study involved a practice setting, although trying to incorporate competition settings by shooting from different areas of the circle, may be the cause of the negative results gained. Although Weinberg et al. (2003) commented that imagery is mainly used by athletes when faced with a difficult situation, which it was felt that the athletes were within a difficult situation by having the feeling of performing well under pressure, it did not mimic the open skilled tasks of a netball game. Although in contrast to this Weinberg et al. (2003) further suggested that for imagery to be effective then it needs to be practiced systematically. The setting in which the research was set, was in a practice condition therefore meeting the suggested setting by Weinberg et al. (2003).

To improve the test scores and to gain a more reliable t-test result it may be suggested that the imagery be practiced systematically in the setting that was used for the primary research but then results gained from a game situation whereby it meets the demands of both the open and closed skills; thereby facing the athletes with a difficult situation.

A final explanation as to why the results appeared as they did may be due to research suggesting that imagery has a larger impact on single player sports, compared to sports such as netball which are team sports. Weinberg et al. (2003) explained from research that single player sports not only utilise the benefits of imagery more frequently but also finding it more effective. This therefore explains that as the players included within this study belong to a team sport there was insufficient evidence to suggest that imagery improved performance.

The findings of this study however refute the literature. The type of primary research that was carried out replicates a penalty shot in a game situation, as Beashel et al. (2001) explained. This type of skill is classified as closed due to the player having more control over the situation. Arvinen-Barrow et al. (2007) wrote that closed skilled athletes utilise the effects of imagery more frequently along with finding it more effective. It would then be expected that the athletes chosen for the current study, due to also having closed skills within an open skilled sport, should have utilised the benefits of imagery during a closed skill. However this is not the case as only half had used imagery previously, therefore indicating why only two out of the six players scored positively after the imagery intervention. Again this refutes the literature written

as Weinberg et al. (2003) expanded that imagery is useful during a repetitive movement within a closed skill environment.

Conclusion

To improve the benefit of using imagery within the netball population then it needs to be systematically practiced as this can be supported by assessing the results of netballers which had previously used imagery compared to the netballers that had not it can be seen that they performed slightly better. Therefore by introducing a systematic practice to all netballers it will enhance performance and accuracy when imagery is implemented during a difficult situation within competition.

The skill level of the netballers did not impact the effectiveness of the imagery intervention upon performance. This is an important finding as during the primary research the author was only able to focus upon a small sample group that did not vary a considerable amount. Although there was a large enough divide to notice that skill level was not a mediating factor. Therefore this indicates that imagery interventions can be applied to a large population of both novice and elite athletes, having the same effects for the differing of levels.

A key finding within this study is that performance did not improve after the imagery intervention. This can be shown in the calculation of mean averages with there being on average 4.3333 goals scored after the intervention compared to 4.6667 goals scored on average before the intervention. The t-test results also reaffirmed that the data collected did not hold any significance. However it is believed that this may be because there was only a small sample size available to the author.

From calculating the correlation co-efficiencies some similarities can be seen between participants 2 and 4 who both scored positively. As they were the only two netballers that scored higher than 1 on the likert scale for question two, which asked how vividly they heard the noise of the crowd, question four they were the only two netballers that scored a five for how clearly they felt their emotions of the situation and finally for question six they both scored this highest of a 3, for viewing themselves as if through a camera. This finding is important as this could be the key to why these two netballers scored positively after the intervention whilst also showing the highest positive correlation co-efficiencies. Therefore if the remaining four netballers had scored more positively on these questions then their scores may have reflected the scores accordingly by also scoring better after the imagery intervention.

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Case Study

Dry Land Training for Kayaking and its Implications on Longevity and Performance

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KEY WORDS

Flat water Kayaking
Land based training
Core stability
Strength Development
Endurance
Power
Flexibility

ABSTRACT

The Purpose of this case study is to outline the importance of dry land training for success and longevity in kayaking. Covering the areas of long term strength and core development, endurance, power and flexibility and the role they play for the kayaking athlete.

The Sport

Flatwater Kayak racing has been an Olympic Sport since 1936, in which the distances of 1000m and 500m are contested. From a stationary start position the athlete is required to paddle the length of the competitive distance in as short a time as possible. Gold medal times at the 2007 World Championships for the men's Single Kayak (K1) 500 metres was 1 min 36.28s, and 3min 40.11s for the K1 1000 metres. Paddling these events places exceptional demands on the upper body and trunk musculature (Tesch, 1983). Previous researchers (Bishop, 2000; Fry & Morton, 1991; Gray, Matheson, & McKenzie, 1995) suggest that flat water kayak paddlers possess high values for maximal aerobic and anaerobic capacities and upper body muscular strength. In a recent review of the metabolic demands of kayaking, (Michael, Rooney, & Smith, 2008) it was concluded that flat-water kayaking is characterised by exceptional demands on upper body performance. A successful kayaker not only requires high aerobic power, but a high anaerobic energy yield and great upper muscular strength. For those not familiar with the difference between kayaking and rowing, when kayaking you face forward in the direction you are going and when rowing you face backwards to the direction you are going.

The Mechanics

From the seated position paddling force is applied through the kinetic chain concept where force is initiated from the lower limbs, transferred via trunk rotation and manifested through the upper limb to the paddle. The leg drive should be synchronised with the trunk and arm action. Ideally at the catch (when the blade enters the water) the same side knee flattens out at the equivalent rate as the arm pulls. During the pull the gluteal muscles are contracting, with reduced involvement contra – lateral to the pulling arm.



Figure 1: A photo of good posture and technique, note the solid connection from the water up the paddle then through the arm, scapular region and torso to solid leg drive.

This enhances a strong connection between the athlete and the seat. As the pulling arm abducts and extends through the power stroke movement the contra-lateral hip is rotating anteriorly with facilitation of force generation via the lower limb through an anchoring and dorsi-flexion movement of the adjoining foot on the footplate strap.

From the start of the movement of the strokes should be a symmetrical motion with the force development in the pulling movements being applied evenly and constantly throughout the stroke. The frequency of the left and right strokes forming what is known as Stroke Rate (SR). The symmetry between the left and right side is vital. Essentially the closer the bilateral power, range of movement and skill the greater the force that can be applied through the water with a resultant increase in boat velocity on the water. At no point throughout the power stroke should there be any breaking of the rigid connection of blade to body to foot plate (Australian Canoeing Flat-water Racing Manual, 2004).



PHOTO: K. Wallace.

Particular attention in the gym program should be paid to the gluteals, hamstrings, hip flexors, lower abdominals, external obliques, transverse abdominals, erector spinae, quadratus lumborum, pectoralis major/minor, sub scapularis, teres major and minor, infra spinatus and supra spinatus and the rhomboids, deltoids, trapezius, biceps, triceps, latissimus dorsi and serratus anterior.

Areas of Importance in Gym Programs:

1. Injury Prevention and Correct Posture

Due to the fact that kayaking is done in the sitting position attention should be paid to the establishment and maintenance of correct posture of the spine, pelvic region, torso, rear shoulder and scapular region. Correct sitting position is essential as good posture prevents the development of many back and shoulder problems that are often associated with paddling. Well balanced uses of the core muscles of the Thoracic – Lumbar – Hip Complex (TLHC) and those that support the scapular are vital. When the muscles of the TLHC and scapular region are contracted correctly they provide a solid base of support for the correct biomechanical application of rotation and power at the extremities as the importance of a paddlers force production and the ability to keep it strong and constant is vital.

Suggested Exercises: Prone Holds, Prone 3 way fly's, Reverse Hypers, Hyper Holds, Lower Abdominal Cycling, Lateral Holds, Reverse Fly's.

2. The Developing Athlete

When constructing a gym program for kayaking and due to the movement pattern and seated rotation involved it would make sense to incorporate the fundamental principles of Long Term Athlete Development (LTAD). Concentration on developing sound technique in the functional triple extension lifts of the squat and dead lift would be of benefit and

should be continued throughout the whole season. The co-ordination of these lifts and added core stability required to do so is similar to the co-ordination required to perform the paddle stroke. Where there should always be a rigid connection of blade to body to foot plate. As the athlete advances I would have a tendency to move towards single leg movements such as the Single Leg Romanian Dead lift. Where correct form and hip stability would be of the utmost importance and something that would transfer into the stability required in keeping the boat even while applying individual leg drive.

Suggested Exercises; Squat, Snatch Squat, Dead Lifts, Single Leg Romanian Dead Lifts, Alternate Snatch Squat.

3. Main Lifts

During the kayak paddle stroke, elite male athletes spend approximately 65% of the stroke in a pulling motion (from the catch where the blade goes into the water to the blade exiting the water) at a 100 stroke rate (SR); this increases to 70% at maximum stroke rate. For elite women this increases 70 – 75% at 100SR and 75 – 80% at max stroke rate (Baker & Sachilkidis, 2008). Due to this large proportion of time spent in the pulling motion a significant amount of kayakers dry-land training would be spent in improving the strength and power qualities of pulling exercises in the belief that it will translate to gains in on water performance. Therefore I would insert more pulling exercises than pushing exercises in a weight program but enough pushing exercises so as not to interfere with the agonist- antagonist muscle balance. During the competition phase of training I would have additional maximum power work concentrating on acceleration and rapid force development in the pulling movements.

Apart from the main upper body lifts of Bench Press, Bench Pull and Chin Ups to be used for strength acquisition, I'd have a preference for assistance strength exercises to focus on co-ordination and specific movement. Single arm dumbbell press and alternate dumbbell press while bridging off a Swiss-Ball in a supine position offers the connection from the floor up through the body and to the weight. Hip stability through the synergistic activation of the gluteal muscles is vital and transfers over to boat stability and power on the stroke. Alternate prone dumbbell pulls with the legs against the wall assist to simulate the kayak paddle stroke through this total connection from weight to torso to the feet. Simulation of the kayak paddle stroke also occurs with a standing bent over dumbbell row with added rotation above the hips. Again the increased recruitment of the stabiliser muscles (erecta spinae, gluteals, internal and external obliques and the thoracic cavity), will carry over to better posture and better boat control.

Suggested Exercises; Bench press, Incline DB Fly, Incline DB Alternate Press, Alternate Swiss Ball Press, Single Swiss Ball Press, Swiss Ball DB pull Over, Chins (weighted and unweighted), Bench Pull, Seated Row, Lat Pulldown,, Alternate DB Pull, DB Pull ups.

4. Core exercises

Apart from the benefits of injury prevention associated with core stability and trunk strengthening exercises the increased recruitment of the stabiliser muscles added with increased strength of prime movers will carry over into better posture which is vital when paddling a kayak (Australian Canoeing Flat-water Racing Manual, 2004). The key training principles of specificity and progression would also apply to the core training with basic static hold core exercises being utilised throughout the yearly program and once mastered more single leg and torso rotational movements added.

The ability to maintain balance while under the additional demands of isolateral and trunk rotation during movement would assist the athlete to generate greater force on the blade. These single leg exercises mimic the leg drive and trunk rotation of the stroke. It has been stated that some static bodyweight exercises that develop strength endurance in specific kayak postures may need to be utilised annually from a pre-habilitation prospective, for example a timed static Hyper hold which progresses to adding additional straight arm dumbbell torso rotations would be of benefit.

Suggested Exercises; Prone Holds, Prone 3 way fly's, Reverse Hypers, Hyper Holds, Lower Abdominal Cycling, Lateral Holds, Reverse Fly's. Static holds that progress with added limb movement and with decreased points of attachment to the ground, Add Rotation to Static holds.

5. Pulleys

The use of pulleys for technical torso work is also of great benefit. The "feel" that the athlete achieves through the connection from the pulley up the arm through good scapular control and transferred proximally or inferiorly depending on body position, through the torso, hips and legs is as close to paddling as their dry land training can achieve without the use of a kayak ergometer. As stated the "feel of total body connection to blade" is the priority during this work and the weight added is minimal as to not deteriorate the technical aspect of the stroke. The use of a mirror is also of benefit as a teaching aid.

Suggested Exercises; Seated Cable Pull, Standing Wood Chops, Standing High/Low Cable Pull, dependent on the machine and the specific imagination.



Basic Yearly Plan (For Australian based non International athletes)

General Preparation Phase of 8 weeks: (August and September) concentrating on hypertrophy. Reps in the range of 8 – 12.

Specific Preparation Phase of 8 weeks: (October and November) concentration on maximum strength and some power development. 3 -6 and 5 – 6 reps in power.

In season Phase of 8 weeks: (December and January) concentrating on Specific strength (dependent on number of double strokes to start 3 6 Reps). A Strength Endurance Session (100 Reps) and a Strength/Power session with a higher number of power exercises increased intensity with decreased volume are included in this phase.(Possible Drop sets; example 3 at Max, then 5 at 60% of max done with speed.

Competition Phase of 6 weeks: (February and March) concentrating on Max Strength maintenance, Power, Acceleration and Speed. (Increased intensity and decreased volume). Reps for Strength Maintenance 3 – 5 Reps. 2 - 5 Reps for Max Power at 45 - 60 % of 1RM Max. 3 - 10 Reps for Ballistic Power done at 30 – 40 % of 1RM Max.

(These figures are slightly different to those suggested by Baker and Newman due to the Stroke Rate Breakdown of the individual Kayaker).

See Appendix 1.

Advanced Training Principles;**Strength Endurance Work**

During this in-season period those who are also competing in Surf Life Saving Competitions get an opportunity to practice their racing at Surf Carnivals and practice improving their mental toughness in doing so. Although I believe that kayak specific strength endurance can be obtained by adding weight to a kayak or applying resistance with tennis balls on a rope around the hull I can see the use of high repetition weight training (in the range of 100 – 120 reps) of benefit. I do realise that the outcome is isolated lactate production and muscle fatigue but when put into a Race Plan situation with realistic figures such as strokes per distance, time taken and force applied, it can be used as a mental tool to harden the athlete.

It has been noted that the importance of a paddlers force production and the ability to keep it strong and constant is vital to performance. The catch needs to be quick and crisp with the power applied even and constantly throughout the stroke. Testing of force production is done by attaching Force Transducers (AIS Biomechanics and Performance Analysis Department) to the paddle and results are given as a force curve with Force (F) measured as (F = Mass times Acceleration measured as Newtons.). These values can then be applied to the gym by dividing the Newtons by Gravity. By using a value of approximately 10 units (as gravity is 9.8 m.s⁻²), a Force of 700 Newtons would equate to 70 kg. If 700(N) were pulled at the start of the race and then an average of 400 (N) were pulled through the middle of the race then the athlete applies 450 (N) at the finish, you could then use these figures to put into your Strength Endurance weight programs.

It is stated that; A male athlete takes on average 100 double strokes (100 each side, total 200 strokes) to complete a 500m K1 race. If the race was then broken down into 10 to 15 double strokes to reach maximum boat speed, (Start), 50-60 double strokes to run the boat through the middle of the race and finally 30 double strokes to come home (Finish) a weight training session can be developed. Using the Bench Pull, an example of a Strength Endurance program with the following values would simulate a race plan; 10 Reps @ 70kg, 50-60 Reps @ 40kg and 20-30 reps @ 45kg. Done as a continuous set of 100 reps. The speed of movement throughout these separate sections of reps would be similar to race pace with a SR of 140 per minute for the first 10 reps then SR 110 for 60 reps and finally SR 120 for the last 30 reps. Total time to complete the 100 reps would be approximately 1 minute 30 seconds.

This would be done with a spotter and 1 bar which would need to be down loaded and up loaded accordingly when the desired repetitions were reached. Time taken to complete

the event could be tested weekly and then attempts at improving this would be of benefit. Working on a 15 minute cycle core exercises could be done in between and 3 sets of work could be completed.

*Please note that this type of training should only be attempted with mature athletes with advanced gym age.

Power Work

Using this principal for power training by concentrating on a 5-10 double stroke start using 70kg as the Force Weight equivalent power training can be utilised using a realistic weight that is relevant to what the specific athlete can pull on water. Four sets of 3-5 reps of ballistic Bench Pull focusing on acceleration and speed with 70kg could be an alternate method to % of 1RM Max. As mentioned I do realise that these exact force weights are only available to a select few but the application of the principle would be of benefit and easily applied with some thought and care. Alternately Baker and Newman (2007) suggest for Power max training 2-3 repetitions at 45–60 % of 1RM or 3-6 repetitions at 30-45 % of 1RM be used for ballistic power training.

Stretching program

Sitting in a kayak and paddling for periods of time can cause all or some of the following problems which can be addressed with an appropriate stretching program.

1. Tight hip flexors, hamstrings and calf muscles.
2. Tightness through the external hip rotator muscles, which can lead to restricted movement at the hip joint.
3. Reduced extension through the lower back, causing stiffness in the mid thoracic spine.
4. Tight and hunched shoulders with weak lower shoulder muscles, tight pectoral muscles and weak muscles at the back of the shoulder.

Immediately after a training session the athlete should paddle back to the pontoon, this can take approximately five minutes and they should definitely make sure that their heart rate has returned to near resting. They should also take on fluid as soon as possible, looking to replace 1.5 times the amount of fluid lost throughout the session. This is calculated by weighing the athlete pre and post training where for every kilo lost a litre of water needs to be replaced. It has been suggested that a fluid containing between 25 to 100 mmol/L of salt assists the fluid replacement. (Typical Australian sports drinks contain between 25 and 50 mmol/L of salt.) Once back at the pontoon they should go for a light bike ride or jog to assist in clearing any extra lactate taking approximately five minutes, this would also assist in lowering the HR to approximately 50-60 % of the Max HR. From here one set of stretches as below will be completed followed by Hot/Cold Showers or

an Ice Bath. Once this is done another series of stretches can be completed.

These stretches would also be completed after the gymnasium sessions.

Stretches (All stretches held for a minimum of 30 seconds)

- Calf Stretch right and left.
- Hamstring Stretch, right and left.
- Gluteal Stretch, right and left.
- Hip Flexor Stretch, right and left.
- Cross Legged lower back twist, right and left.
- Cat Stretch, slow rise and fall 10 times.
- Pec Minor Stretch, right and left.
- Rhomboids Stretch.
- Lat Stretch.

Practical Applications

In conclusion Ackland et al. (2003) noted that sprint kayak paddlers possess unique characteristics not commonly observed in the general population. These include a lean body composition with proportionately large upper body girths. Benton, (2003) stated that functional development is the improvement of an athlete's ability to operate their musculoskeletal system (body), especially in relation to the sport, it relates to posture, mobility, motor efficiency and body awareness.

With this in mind I hope that I have given an insight into the areas of importance in relation to kayak paddling and how I feel they could be approached in a dry land training environment.

They include:

1. The incorporation of the fundamental principles of Long Term Athlete Development (LTAD) and the use of triple extension exercises.
2. Core exercise development and their progressions for injury prevention and body functionality.
3. A program that does have a tendency to concentrate on more pulling exercises than pushing, particularly during the competition phase.
4. With advanced athletes a sound yearly plan with specific phases of work which concentrate on progress through hypertrophy, max strength, strength endurance, power development and it's partners acceleration and speed.
5. A comprehensive stretching program.

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Reviews and invited commentary

Research concepts and methods – 3

Quantitative and statistical aspects of data variables

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KEY WORDS

Research philosophy
Research paradigms
Research methods
Research methodology
Complementarity of method
Positivism
Interpretivism
Critical Realism
Subjectivity
Objectivity
Qualitative data
Quantitative data

INTRODUCTION

At the conclusion of research concepts and methods – 2 in the Journal of Sports Therapy (JST) volume 3 (2), I referred to the various categories and families of data variables, and how a basic understanding of their characteristics and behaviour may assist us in the selection and deployment of the most appropriate data samples for quantitative research. You may recall in the same article I also discussed the opportunities and benefits of considering a four-way research matrix, where quantitative and qualitative input variables can be translated into both qualitative and quantitative response variables or outputs, for analytical purposes. And, in of the next four articles, I will explore each of these combinations in turn, with a particular emphasis on the utility and advantages of considering the complementarity of methods rather than the mutually-exclusive approach of selecting either quantitative or qualitative methods in the design and construct of research methodologies. However, in this issue, I focus largely on quantitative and statistical aspects of data variables, and attempt to articulate this by offering two summary illustrations as reference points. With this in mind, the following section discusses the typology of raw data and data scales, and highlights some of the questions the researcher needs to ask in relation to establishing the necessary answers, or responses, from which the raw data can be drawn, section three offers a statistical utility framework, with the final section given over to the two table illustrations described above.

A typology of raw data and data scales

The first question the researcher needs to ask relates to whether discrete or continuous raw data is required for organising into information and analysis. Discrete data is often unordered, and usually represented by whole numbers; for example, the number of children in a family or the apples on a tree, whereas continuous raw data may be represented by whole numbers (integers), but more usually will have infinite or continuous calibrations in between them. For example a person's height may be measured at 1.6 metres rounded to one decimal point, or 1.5678775643... ∞ metres without rounding. And here is the first decision-making point regarding raw data selection; if the researcher merely required to register the numbers of individuals who were over 1.5 metres, and those under that height then discrete data would suffice. There would so many above, so many below, and effectively then the data gathered would be limited to categorical analysis with the researcher deciding beforehand the sort of responses (answers) required to generate such data, and thereby determining the necessary questions to ask in order

to elicit these answers and therefore this particular type of data. On the other hand, should there be need to use statistical methods of analysis, continuous data would be required because the departure point for most parametric² statistical methods is establishing the arithmetic mean and standard deviation, and sometimes also the range, and quartile or percentile spreads. Here, the questions required to generate this type of raw data would need to take the form of what is the height of the individuals in metres, centimetres, and maybe millimetres.

Once the types of raw data are established, the second level of enquiry should focus on the scale of the data types, and there are four types: nominal scales, ordinal scales, interval scales, and ratio scales. Of the four, three can be employed in statistical analysis, with nominal scales confined to qualitative analysis only. Nominal or categorical scales are where numbers are allocated to label, or name, a variable. In this sense they are used to reflect a classification of data or

¹ The symbol ∞ denotes infinity in mathematics

² Parametric and non-parametric methods are discussed in the next article in the series, but for the purpose of this article parametric means analysis using samples and populations with predetermined sample sizes based on probability and distribution shapes

objects; house numbers, gender, socio-economic group etc. Ordinal scales do everything that nominal scales, but also offer a form of ordering the data by assigning values that indicate or reflect a ranking. For example, the Likert scale is often used in questionnaires to illustrate attitudes 1 = strongly disagree, 2 = agree, 3 = unsure, 4 = agree, and 5 = strongly agree. These are very useful scales, and are often used in tandem with nominal scales. However, they are of limited use statistically because they offer no indication of distance between the rankings, and therefore cannot be arithmetically manipulated or employed comparatively or relatively. Interval scales do everything that nominal and ordinal scales do, but additionally offer a consistency of measurement between the points on the scale, and are always the same. So, on a thermometer the difference between 15 degrees Celsius and 20 degrees Celsius is the same as the difference between 45 degrees and 50 degrees. The problem here is that because we have open ended scaling that contains sub-zero, or minus temperatures, we cannot accurately say how much hotter 40 degrees Celsius is than minus 20 is, we can only measure the distance of 60 degrees. However, ratio scales can be used to measure relative distances between points. Take a simple example of a 30 centimetre ruler. Here we have a clearly defined beginning and end, unlike the temperature (interval) scale, where there is a lower limit, 0 centimetres, and an upper limit of 30 centimetres, which means that we can confidently say that 20 centimetres is twice as long as 10 centimetres, and that 5 centimetres is a fifth of 25 centimetres.

Statistical utility

It is therefore important that the researcher establishes not only the type of data that is required, but also the answers that are needed to generate those data, and the questions required to give rise to those answers. However, before these items are even considered, the question of how the findings of the research are intended to be structured must be addressed, and before that, there is the need to identify the mode of analysis that will best generate such structures; and this means considering how the raw data should be organised into information, and how this information can be analysed. In the realm of quantitative analysis, this means statistics. Statistics relate to samples, and parameters relate to populations, and we use statistics to consider relationships, and to make observations, comparisons, and predictions.

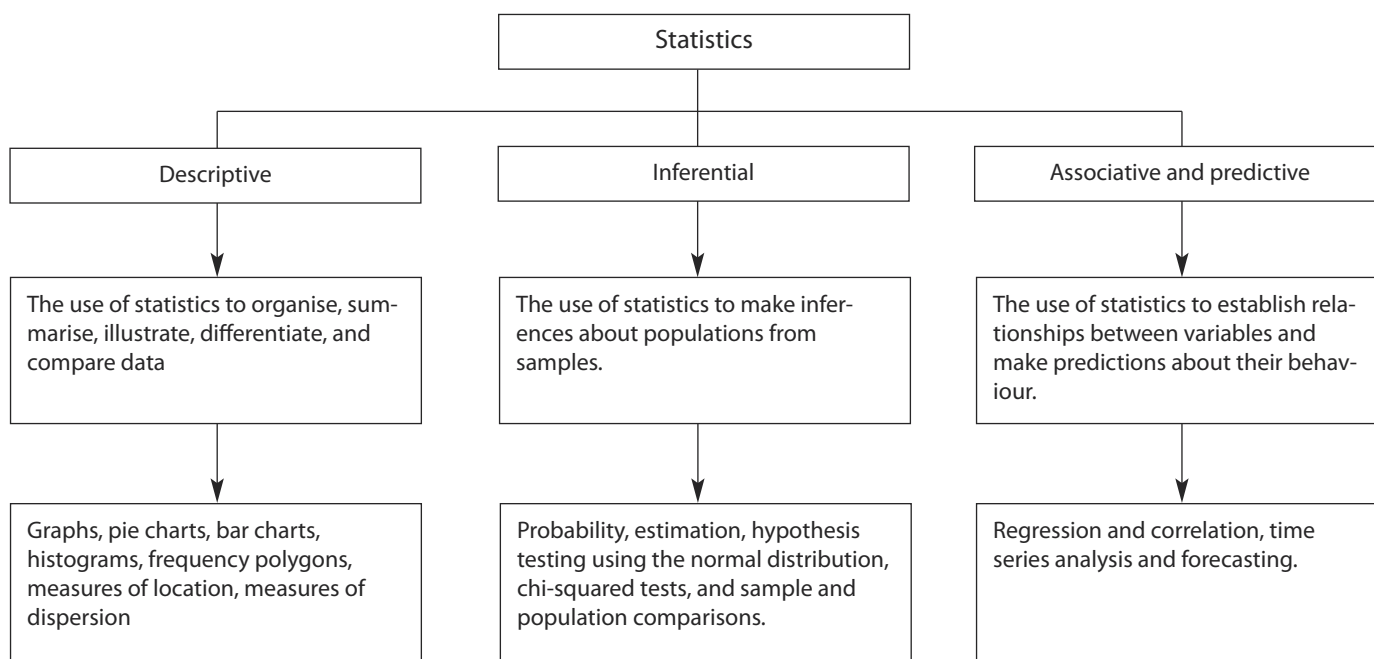
Summary

Below, I in figures one and two illustrate both the data typology discussed above in relation to statistical utility, and also a statistical utility framework. These are designed as reference points from which to consider issues surrounding data collection and generation, method constructs, and methodology formation in research designs.

In the next issue of JST I will examine the first of the four combinations discussed in issue 3 (2), that of quantitative inputs and quantitative response variables, or outputs, and associate statistical methods.

Figure 1: Data typology

Data type	Description	Discrete or continuous	Qualitative or quantitative	Statistical utility
Nominal	Numerical values that identify or label discrete categories	Discrete	Qualitative only	Categorical. Potentially descriptive.
Ordinal	In addition to nominal characteristics, these numerical values identify rank or order	Discrete	Qualitative and quantitative	Categorical. Potentially descriptive and associative
Interval	In addition to nominal and ordinal characteristics, these numerical values identify distances between values, but not ratio comparatives	Discrete and continuous	Quantitative only	Numerically and mathematically operational. Potentially relational, inferential, and predictive
Ratio	In addition to nominal ordinal, and interval characteristics, these numerical values also identify comparative ratios	Discrete and continuous	Quantitative only	Numerically and mathematically operational. Potentially relational, inferential, and predictive

Source: primary**Figure 2:** A statistical utility framework**Source:** primary

Notes to contributors

Manuscripts, 3,500 words maximum for papers, and 1,000 maximum for discussion articles and book reviews, should be submitted to JST@ucb.ac.uk in Microsoft Word© format.

Contributors should confirm at point of submission that their article is not currently under consideration for publication elsewhere, and should be aware of the copyright, clearing permissions, and the disclaimer laid out in the terms and conditions below

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Presentation of the paper

Articles should be in English, dated, typed in Times New Roman, font 12, and double-spaced including all notes and references. Articles should not normally exceed the above-highlighted word limits. Please include an indication of the word count at the end of the text, together with the date of the manuscript. Also, contributors are asked to provide an abstract of 50-100 words with the article, plus a list of up to 6 keywords suitable for indexing and abstracting services. Finally, please append authors' full postal and e-mail addresses, as well as telephone and fax numbers.

Notes

Keep textual notes to a minimum, indicate them with superscript numbers, and provide the note text as a list at the end of the article before the references. Please do not use footnotes.

References in the text

Using the Harvard system, in the text, refer to the author(s) name(s) (without initials, unless there are two authors with the same name) and year of publication. Unpublished data and personal communications should include initials and year. Publications which have not yet appeared are given a probable year of publication and should be checked at proof stage on author query sheet.

Example:

Since Paterson (1983) has shown that ... This is in results attained later (Kramer, 1984: 16). Results have been reported (Robinson, 1989, personal communication) which suggest

Publications by the same author(s) in the same year should be identified with a, b, c (e.g. 1974a, 1990b) closed up to the year. If there are two authors for a publication, put both names separated

by 'and' (not &). If there are more than two authors, put the name of the first author followed by et al. References to material on the internet must be given in brackets in the text, not in the reference list. The full URL must be given.

Example:

www.nature.com/onc/v18/n1/1234567.html

List of references

References are placed in alphabetical order of authors. Examples of correct forms of references for alphabetical style:

Paper in journal

Higgott, R. (1998) 'The Asian economic crisis: a study in the politics of resentment', *New Political Economy* 3(3): 333-336.

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