Differences between Intermittent Pneumatic Compression and Dynamic Warm-Up on Leg Muscle Strength in Young Healthy Adults

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Abstract: *The effects of Intermittent Pneumatic Compression (IPC) on muscle recovery have been established. Limited evident to reveal the IPC modality effective in muscle performances. In this study, it was aimed to observe whether the IPC can be effective for leg muscle strength performance in young healthy adults. This observational study is to evaluate the differences between IPC and Dynamic Warm-Up (DW) on leg muscle strength performance, in young healthy adults. A total of fourteen (n=14) male participants aged range between 20-27 years underwent IPC and DW intervention at separated trials weeks. Participants performed isokinetic dynamometer following each of the IPC and DW treatments. The outcome measures of the leg muscle strength performance taken peak torque of knee flexion (Hamstring strength), peak torque of knee extension, Hamstring to quadricep (HQ) ratio. Results indicated no different between IPC and DW on all outcome parameters (p=>.05). This conclude that IPC did not different than DW on leg muscle strength performance in young healthy adults. Thus, further research is needed to unravel whether the IPC can be effective modalities in enhance muscle performance.*

Keywords: Intermittent Pneumatic Compression, performances, muscle strength, recovery

1. INTRODUCTION

Intermittent Pneumatic Compression (IPC) frequently used, particularly by athletes to enhance recovery from strenuous exercise [1]. The IPC have sleeves attach to a to the body part and inflate and deflate around 20 to 60 seconds. The compressed areas tissue by the nylon sleeve to increase the blood flow to the body parts from proximal limbs to distal extremities. The pneumatic pressure designed by the mimic of compression feelings of hand pressure massage. The idea of inflating and deflating movement of the IPC device was aim to promote the circulation of the and enhanced the removal of waste product after the exercise. In research, the used of IPC mainly found was for muscle recovery. Previous demonstrated the IPC modality was effective for muscle blood flow and improve muscle stiffness and fatigue in muscle to recover in athlete performance [2]. Another recent study supported this evidence that showed IPC enhanced performance in footballer by reduced muscle soreness, and promote faster recovery [3]. Moreover, IPC devices explained that the recovery of the muscle because of the improve skin blood flow, reduce oedema, and lower venous pressure while raising venous velocity [4-6]. Besides it can improve the physiological parameters, IPC also recorded to improve the range of motion of the joint, reducing discomfort and oedema following exercise, and minimizing delayed onset muscle stiffness [7]. It is important to note that while IPC is commonly used by athletes for recovery, the effectiveness of this modality for muscle performance is still ambiguous and further research is needed to fully understand its benefits and limitations.

Despite widespread applicable use, systematic reviews and meta-analyses reveal inconsistent functional benefits of pressure-based recovery modalities. A recent meta-analysis of lower-limb IPC reported only small, non-significant gains in objective muscle function, even though with moderate subjective recovery enhancements [11]. Likewise, IPC shows variable effects on strength recovery, and high-quality comparisons among available techniques lack of resources [12].

In sports performance the leg strength (LS) is an integral part of optimizing athlete performance. Leg muscle serves as a central part of perform various dynamic activities, loading and lifting tasks. LS is a critical physical attribute to optimizing athletic performance [8]. Other studies also supported that LS play important role in higher levels of professional play in basketball game.[9].

The current literature found IPC mainly used and effective in muscle recovery. Limited study to discover the effectiveness of IPC use for increase muscle strength performance. It is interesting that insight of the use IPC on increase muscle strength can be elucidated. Thus, this study aims to observe the IPC use the leg strength performance. To achieve the objective of this study, dynamic warm-up (DW) known as standard activity to improve functional strength performance healthy young adults. Hence the comparison between IPC and DW following leg strength performance is investigated.

2. METHODS

A total of fourteen healthy young adults' males participated in this study (ages: 22.79 ±1.85 years-old, height: 169.43±0.04 cm, weight: 64.33±7.60 kg). All participant is actively involved in sports and free from any lower limb injury for the last 6 months. All participants provided written informed consent prior to participation in accordance with the research ethical approval obtained from the institutional research ethics committee (Ethical approval reference number: 600-FSR(PT.5/1/SR241/S2A)).

In this study, participants performed IPC and DW as treatment intervention in the Human Performance Laboratory FSR with control room temperature [16]. The DW is set as control group treatment. The IKD was used as test outcome following the treatment intervention (IPC and DW). The experimental test was designed in two different weeks due to implement washout period from post muscle soreness and fatigue. During the one-week rest period, all participants were instructed to stay healthy and did not participate with any sports competition. The test design is presented in Figure 1.

Fig. 1. Flowchart

Familiarisation
(Week 1)
-IPC
-IKD
-DW

↓

1st Treatment
(Week 2)
-IPC
-IKD
(Con@60°/s)

↓

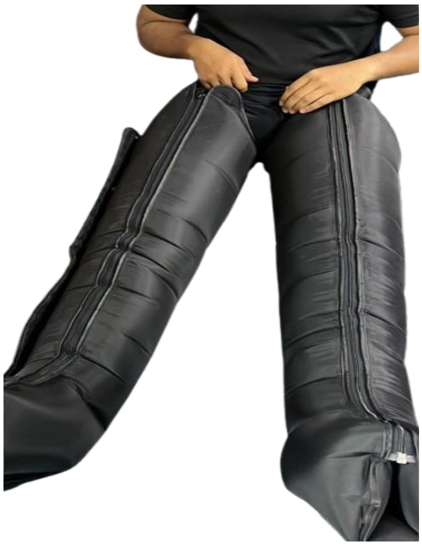
2nd Treatment
(Week 3)
-DW
-IKD
(Con@60°/s)

1st=First, 2nd=Second, IKD=Isokinetic Dynamometer, IPC=Intermittent Pneumatic Compression, DW=Dynamic warm-up, Con=Concentric, @=at, °/s=degree per second.

2.1 IPC Device

A prototype version of ATF Healing boots (ATF sports, Malaysia) in figure 2 was used for IPC application in the both lower limbs in this study. These devices cover the entire leg when the participants laying on the with their feet elevated at the same level as the hips during the intervention [13]. For this study, the IPC treatment used 6 compression/min (2s inflation/3s deflation) at a pressure 160 mmHg recommended by ATF.

Fig. 2. IPC



Participant performing IPC in the recumbent sitting with their feet elevated at the same level as the hips.

2.2 Dynamic Warm-up

The participants perform standing leg stretch for 8 repetitions each leg, front lunges for 4 repetitions each leg, hamstring stretch 8 repetition each leg, leg raises for 4 repetition each leg. All dynamic stretch performing 3 set and 10 second rest in between repetition and set.

2.3 Isokinetic Dynamometer (IKD)

Leg muscle performance was evaluated in quadricep and hamstring muscle group using isokinetic dynamometer (IKD) (Prima Plus, Easytech, Italy). The position of participants on multi-joint system was seated with the backrest angled at 90° to the seat with their hands grip the handle beside the seat. To minimize body movement of knee joints and ankles, specific belts were placed across the thighs, the pelvis and shoulders. Eligible parameters were maximal isometric bilateral knee extension at 90° of extension, maximal isokinetic bilateral knee extension and flexion with a range movement of movement between 0° (anatomic 0°) to 85° of knee flexion.

This machine in figure 3 records three outcome parameters such as: 1) peak torque of knee flexion (Hamstring strength); 2) peak torque of knee extension (quadricep strength); 3) Hamstring to quadricep ratio (HQR). The muscle torque was expressed as a relative measure (Nm/kp) to eliminate the interfering influence of body weight. HQR was expressed as a percentage value (%). Peak torque was measured in concentric and eccentric mode at angular velocities of 60 degrees per second (°/s). The participants perform six repetitions of maximum effort and take the highest peak torque [15].

Fig. 3. IKD

Participant performing IKD testing

3. RESULTS

The demographic characteristic of participants shown in Table 1.

Table 1: Demographic participants

CHARACTERISTIC	TOTAL GROUP (N=14)
	Mean ± SD
AGE (YEARS)	22.79 ±1.85
HEIGHT (CM)	169.43±0.04
WEIGHT (KG)	64.33±7.60

N=Total numbers, CM=Centimetres, KG=Kilogram, SD=Standard deviation

The demographic characteristics of the study participants presented in Table 1. A total of 14 male participants with age mean of the participants were 22.79 ± 1.85 years. The mean height of the participants was 169.43 ± 0.04 cm and the mean body weight was 64.33 ±7.60 kg.

Table 3 shown the differences between IPC and DW on leg muscle Strength.

Table 3: Differences between IPC and DW on leg muscle strength

Condition (N=14)	IPC (Mean ± SD)	DW (Mean ± SD)	Sig.
Peak torque Hams. (Nm)	113.14	120.29	0.73
Peak torque Quads. (Nm)	164.93	160.50	0.79
HQ Ratio	0.69	0.71	0.74
Max. power Hamstring	108.07	109.78	0.98
Max. power Quadricep	151.85	149.71	0.88

N=Total numbers, IPC=Intermittent Pneumatic Compression, DW=Dynamic Warm-up, Sig.=Significant, SD=Standard Deviation, Hams=Hamstring, Nm=Newton meter, Quads=Quadriceps, HQ=Hamstring Quadricep

The normality test confirmed that is significant non-normality of Peak torque Hams. (Nm), Peak torque Quads. (Nm), Max. power Hamstring, Max. power Quadricep between IPC and DW ($p<.05$). However, only HQ Ratio showed with normality data between IPC and DW ($p>.05$).

4. DISCUSSION

The purpose of this study was to determine the differences between IPC and DW on leg muscle strength performance in young healthy adults. This study indicates the used of IPC was no different to the DW on leg muscle strength performance among young healthy adults. The finding of this study may implicate that both interventions did not improve the leg muscle strength performance following IPC and DW intervention. A likely explanation could be short bout duration of muscle lifting to measure the quadriceps and hamstring strength in IKD may not offer additional benefits following used of IPC. The measurement of leg muscle strength used by IKD protocol was based on short interval of less than 20 sec to complete the test duration. During 20 second of test trials, only 6 reps of lifting concentric and eccentric was performed. This duration period of test trials mainly fuels the muscle with anaerobic energy system and beginning window of the lactate production. Whereby the IPC was largely reported in literatures that the used based on post chronic effect of exercise modalities [11]. For instances, most of the previous studies indicate the effectiveness following IPC intervention as post exercise recovery modality. Thus, the waste product removal and improved blood flow following long duration games and post matches recovery may not effective for acute effect of muscle strength performance. Further research is needed to confirm whether the consequence effect of following IPC modalities in leg muscle strength endurance could be elucidated in preparatory athlete performance.

This outcome may stem from the nature of isokinetic testing, which isolates single-plane concentric actions without requiring rapid directional changes or complex neuromuscular coordination. Analogous to straight-line sprint assessments in footwear research [14], the absence of multidirectional or reactive components likely diminished any differential effects of enhanced limb perfusion on torque generation. Consequently, the protocol's focus on isolated joint movements may have limited its sensitivity to detect subtle performance benefits attributed to circulatory enhancement.

Although IPC is well documented for augmenting blood flow and reducing post-exercise muscle stiffness [4,6] these vascular effects did not translate into measurable gains in isokinetic strength during short-duration testing.

Previous investigations have reported that acute IPC can increased arterial diameter and venous velocity [2] yet such hemodynamic improvements appear more relevant to recovery dynamics than to immediate force output. The current findings align with earlier study showing that IPC applications fail to show improvement in performance[1].

The standardized pressure of 160 mmHg used in our IPC protocol was selected to mimic therapeutic compression levels recommended by device manufacturers. It was hypothesized that this magnitude would enhance muscle–tendon compliance and facilitate greater torque through improved mechanical interlocking within muscle fibres. However, our data indicate no significant differences between IPC and DW conditions, suggesting that a single 6-minute IPC session may not induce sufficient tissue deformation to affect immediate maximal voluntary contraction. This contrasts with studies examining longer-term IPC usage, which have demonstrated reductions in muscle stiffness and improved contractile efficiency over repeated sessions [7].

Our IPC cycle comprising 2 s inflation and 3 s deflation at six cycles per minute was intended to optimize metabolic waste clearance via rhythmic compression [6]. While such patterns have been linked to accelerated removal of by residual biproducts like lactate during recovery phases, they did not reveal acute strength benefits in anaerobic testing context.

The six-repetition protocol of the isokinetic dynamometer relies predominantly on phosphagen energy pathways, leaving minimal opportunity for IPC-mediated enhancements in oxidative metabolism to influence peak torque. Thus, IPC's circulatory advantages may be better suited to endurance or recovery outcomes than to brief maximal strength assessments.

In interpreting these findings, several limitations of the current study should be acknowledged. First, the sample comprised just fourteen young healthy male participants, which may limit generalizability to female athletes, older adults, or clinical populations. Second, only a single IPC protocol (160 mmHg pressure with a 2 s inflation/3 s deflation cycle) and one standardized dynamic warm-up routine were evaluated, alternative pressure settings, cycle durations, or exercise sequences might yield different results. Third, strength assessments were confined to concentric peak torque at a single angular velocity (60°/s) on an isokinetic dynamometer, excluding eccentric performance and functional movement patterns common in real-world athletic activities. Fourth, the prototype IPC device used may differ mechanically from commercial systems, potentially affecting pressure delivery and comfort. Fifth, the crossover design included a one-week washout period, yet residual training adaptations or learning effects during dynamometer familiarization could have influenced torque values. Finally, environmental conditions such as room temperature and participant hydration were not strictly controlled, which may have introduced variability in muscle performance

Considering the scope and outcomes of this investigation, several avenues warrant exploration in future work. Subsequent studies should extend beyond single-velocity concentric assessments by incorporating multiple angular speeds and eccentric torque measurements to capture a fuller picture of muscle performance. Varying IPC parameters—such as comparing 120, 160, and 200 mmHg pressures or testing longer inflation–deflation cycles—over repeated sessions may clarify dose–response effects on both acute strength and recovery. IPC with functional tasks (e.g., vertical jumps or agility runs) could assess real-world transferability. To enhance generalizability, future trials should recruit diverse cohorts, including female participants, older adults, and clinical populations, since vascular and muscular responses to compression may differ by age, sex, or health status. Comparing IPC against alternative warm-up modalities—such as foam rolling or ballistic stretching—would identify optimal preparatory strategies for performance and recovery. Moreover, future protocols should consider crossover designs with extended washout periods and standardized familiarization sessions to minimize carryover and learning biases.

This is the first study to explore the IPC and muscle performance. The outcome of this study opens a gap of future research on testing muscle endurance outcome following IPC could be interesting. The IPC used also is local innovative made which can explore more research especially on different mode of program could be tested on different physical performance attributes.

The IKD protocol designed on the short period of maximum lifting during the test. Future research should adapt the protocol-based endurance/aerobic muscle strength lifting of IKD to the see the effectiveness of IPC use. Lastly, a larger sample sizes and high elite athletes is needed to confirm these findings and explore potential differences in various subgroups, such as athletes versus non-athletes, different age groups, or individuals with varying baseline fitness levels.

5. CONCLUSION

This study confirms the IPC did not improve the leg muscle strength performance compared to DW in young healthy adults. These findings still offer ongoing discussion about IPC modality can be used effectively in enhance muscle strength performance. Future research should continue to explore these methods in diverse populations and settings to fully understand their benefits and limitations.

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