Ground Force 360 Device Efficacy: Perception of Healthy Subjects

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Contents

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Introduction

Given the high incidence of injury to the anterior cruciate ligament, medial collateral ligament, menisci, and patellofemoral joint during athletic activity participation, greater focus needs to be placed on improving knee injury prevention training programs. Traditional open kinetic chain knee extension-flexion exercises are ideal for training or measuring isolated sagittal plane quadriceps femoris and hamstring muscle group strength, power, and endurance. However, neuromuscular training that isolates activation of either of these muscle groups may compromise the natural co-activation needed to provide three-dimensional dynamic knee stability during athletic movements. Functional closed kinetic chain lower extremity therapeutic exercise movements while providing rehabilitation clinicians with a creative "palette" from which to design tasks that simulate athletic performance, may not provide a safe method to progressively increase resistance in a manner that adheres to the specific adaptations to imposed demands (SAID) principle of neuromuscular training [2, 3, 8, 14]. For these reasons, rehabilitation clinicians should blend both exercise modes into treatment plans designed for knee injury prevention or in therapeutic exercise strategies following knee injury or surgery.

Most current therapeutic exercise interventions for knee injury prevention purposes focus either on primarily uniplanar (sagittal plane) movements, or low load multi-planar functional exercise movements [20, 25]. The first group while optimizing the volume of neuromuscular recruitment does not optimally relate to the (SAID) principle as it applies to intensity, movement path, velocity, neuromuscular activation mode, etc. The second group enables greater freedom of movement during exercise performance; however, the exercise intensity, movement paths and velocities, joint loads, and neuromuscular challenges are difficult to control particularly during early knee injury prevention training or rehabilitation. Additionally, many conventional exercise modes do not adequately integrate lumbopelvic, hip, and core region neuromuscular function with lower extremity function, which is deemed vital to knee injury or reinjury prevention [29, 30]. For these reasons rehabilitation clinicians are

M.N. Doral et al. (eds.), *Sports Injuries*,
DOI: 10.1007/978-3-642-15630-4_49, © Springer-Verlag Berlin Heidelberg 2012

continually seeking exercise modes that better translate into specific functional capabilities such as improved dynamic knee stability during jump landings.

Noncontact athletic knee injuries are often associated with single lower extremity jump landings which create three-dimensional loading responses from a variable combination of anterior pelvic tilt, contralateral pelvic drop, and associated trunk movements, femoral internal rotation, knee valgus, tibial internal rotation, ankle dorsiflexion, and foot pronation. This is particularly a concern among athletic females where effective coordination of these thigh-leg transverse and frontal plane rotational couples appear to be more constrained and have less variable presentations [21], while hip and knee flexion angles tend to be reduced and coxa varus-genu valgus is increased [1]. From this knowledge the medical and rehabilitation communities have developed a better appreciation for the multiple linkages that are essential to facilitate dynamic knee stability during many athletic movements. Of particular concern is the capacity for controlling and dampening the three-dimensional lower extremity loading forces that occur following initial ground contact during single lower extremity jump landings. This neuromuscular control and dampening is largely provided by efficient, coordinated eccentric neuromuscular activation of core, lumbopelvic, hip, knee, and ankle region muscles and muscle groups. Powers et al. [22] have shown that patellofemoral joint alignment and stability during lower extremity weight bearing function is largely determined by changes in femoral trochlea position via long axis transverse plane femoral internal rotation. Neuromuscular control of this movement is largely provided by the pelvic deltoid muscles (gluteus maximus, gluteus medius, and tensor fascia lata). Lindstedt et al. [17], LaStayo et al. [15, 16] and Gerber et al. [10–12] have demonstrated how progressive eccentric knee and hip extensor loads applied by a motorized recumbent cycle ergometer type device can improve eccentric lower extremity strength in a manner that improves both gluteus maximus and quadriceps femoris neuromuscular function, increases lean muscle mass, and decreases fall risk. Their device, however, while providing sagittal plane loads to maximize the volume of neuromuscular recruitment, does not replicate the three-dimensional loads that occur during single lower extremity jump landings.

Establishing or improving three-dimensional single lower extremity dynamic stability during torsional loads is essential to knee joint health [14]. Adaptive responses in all connective tissues to progressive loading are largely based on the characteristics of the applied loads (magnitude, direction, velocity, duration, etc.). The Ground Force 360 Device was designed to provide a weightbearing method for applying progressive three-dimensional (primarily frontal-transverse plane) loads in a low impact, functionally relevant manner. This computerized device uses compressed air to provide progressive resistance within user-selected range of motion arcs. A touch screen enables the selection of either one-way concentric, two-way concentric, or concentric-eccentric training modes (Center of Rotational Exercise, Inc., Clearwater, FL, USA, www.rotationalexercise.com). This study evaluated the perceptions of subjects who performed standard, harness-based training in the Ground Force 360 Device. While standing in the resistance harness the Ground Force 360 Device can provide progressive two-way concentric (Fig. 1) or concentric-eccentric resistance as the subject performs whole body long axis rotation. A touch screen enables quick exercise mode, range of motion, and resistance level adjustments (Fig. 2).

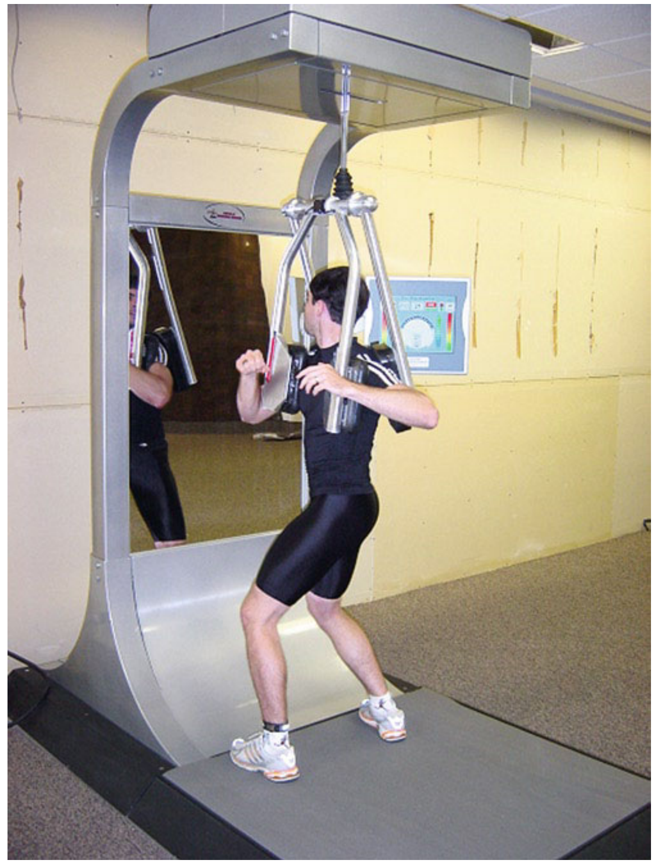

Fig. 1 Two-way rotation in the Ground Force 360 Device

Study Purpose

The prospective study evaluated the perception of 18 (9 men, 9 women) healthy, athletically active subjects following 9 Ground Force 360 Device training sessions over an approximately 4 week study period.

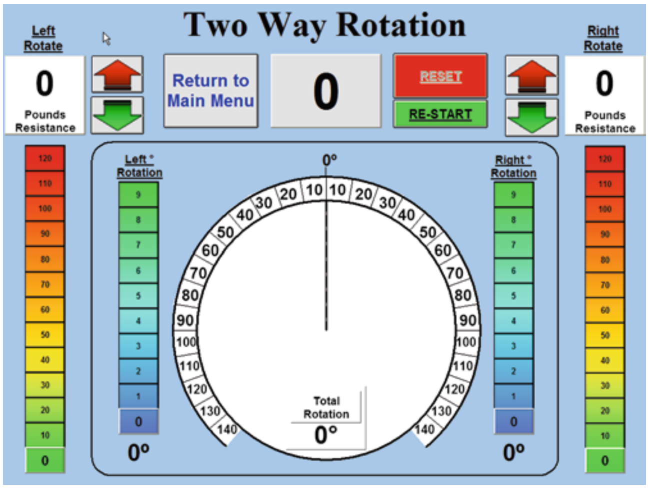

Fig. 2 Two-way rotation using Ground Force 360 Device accessory handles

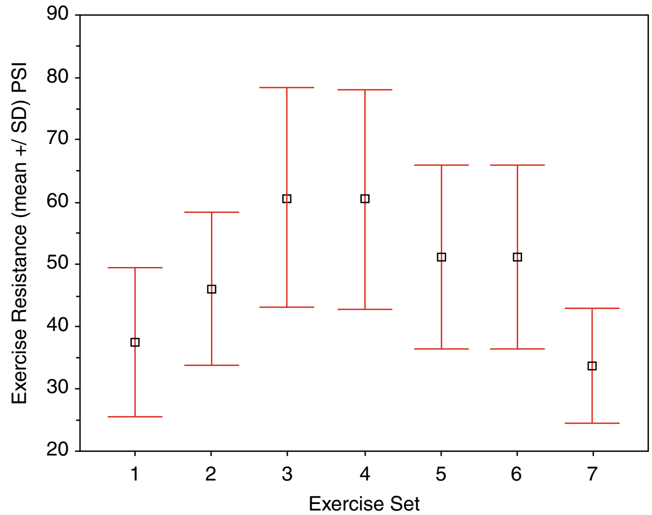

Fig. 3 Exercise resistance for each exercise set (mean ± standard deviation). PSI = lbf/in²

Study Methods

Institutional review board approval was sought and obtained. Subjects provided informed consent. Subjects were 22.3 ± 2.3 years of age, 173.7 ± 10 cm height, and 70.0 ± 9.4 kg bodyweight. Subjects continued to participate in their regular athletic activities while not increasing existing training volume. Over an approximately 4 week period subjects performed two or three training sessions per week on the Ground Force 360 Device for seven total sets during each approximately 20 min duration session. Exercise sessions always began with a 10 min warm-up on a stationary bicycle at a self-selected comfortable pace and self-selected stretching activity for 10 min. The following progression was followed on the Ground Force 360 Device for sessions 1–5: Set 1. Light, bilateral concentric resistance, standard foot placement (20 repetitions) (standard foot placement = athletic ready position stance with feet at or slightly greater than shoulder-width apart), Set 2. Moderate, bilateral concentric resistance, standard foot placement (10 repetitions), Set 3. Moderate to heavy, concentric-eccentric resistance, standard foot placement (10 repetitions), Set 4. Moderate to heavy, concentric-eccentric resistance, standard foot placement (10 repetitions), Set 5. Moderate, concentric-eccentric resistance with diagonal (stride) foot placement (10 repetitions) (stride foot placement = stride position with left foot forward for concentric left rotation and with right foot forward for concentric right rotation approximately shoulder-width apart), Set 6. Moderate, concentric-eccentric resistance with diagonal (stride) foot placement (10 repetitions), Set 7. Moderate to light, bilateral concentric resistance with standard foot placement (20 repetitions). For sessions 6–9, Set 6. was changed to moderate, one-way concentric resistance, and the repetition goal for each set (1–7) was changed to 15, 8, 8, 8, 8, 8, and 15 repetitions, respectively. To achieve desired perceived intensity levels resistance magnitudes were established using a Borg Perceived Exertion Scale [4]. Resistance (Figs. 3 and 4) and whole body long axis (transverse plane) rotational range of motion (Fig. 5) was progressively increased as tolerated. Peak device resistance is 120 lb/in. (8.44 kg/cm²).

Following training program participation subjects completed the following survey:

1. Having trained on the exercise device what would be the likelihood that you would use it if it was available to you at your gym or health club? (Select the number that best represents your opinion)

Not likely					Not sure					Very likely
0	1	2	3	4	5	6	7	8	9	10

2. How useful do you believe that training on this exercise device would be to prepare someone to participate in sports such as football, basketball, tennis, or soccer? (Select the number that best represents your opinion)

Not useful					Not sure					Very useful
0	1	2	3	4	5	6	7	8	9	10

3. What feature did you find most appealing about the exercise device?
4. What feature did you find least appealing about the exercise device?

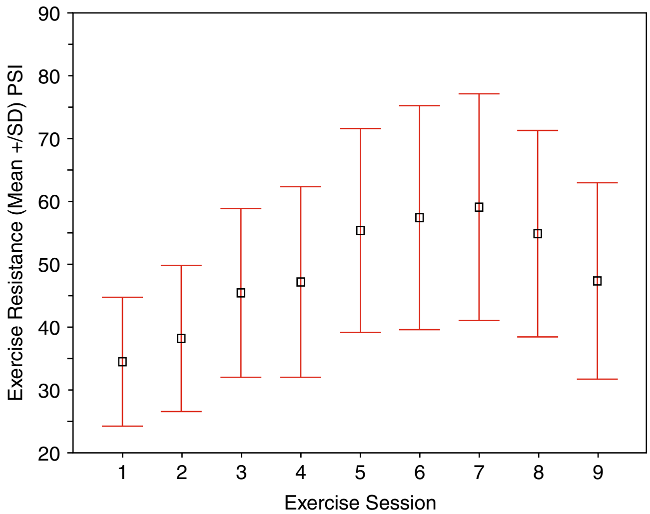

Fig. 4 Exercise resistance for each exercise session (mean ± standard deviation). PSI = lbf/in^2

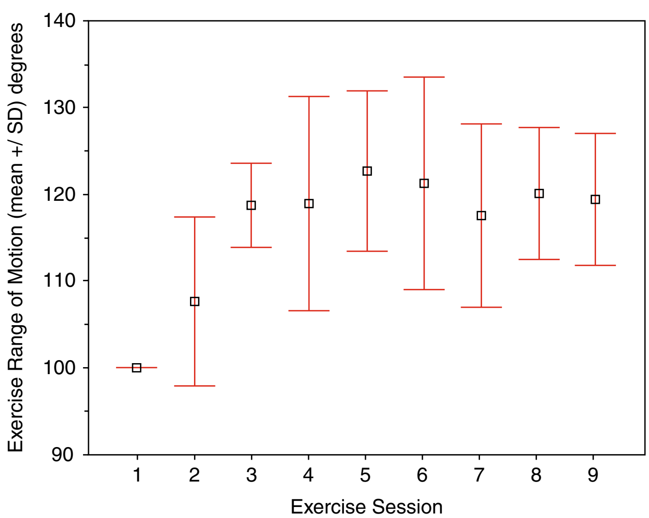

Fig. 5 Whole body transverse plane rotation range of motion for each exercise session (mean ± standard deviation)

5. What group of individuals do you believe would benefit most or least by including use of this exercise device in their training program?

Results

In response to question #1 these healthy subjects rated their likelihood of using the device if it was available to them at a gym (mean ± standard deviation) 7.1 ± 2.1 (range = 3–10). This suggests that they were somewhat likely to use it. Regarding subject perceptions about the device being a useful method of training for sports such as football, basketball, tennis, or soccer, subject ratings were 8.2 ± 1.2 (range = 5–10). This suggests that subjects believed that it would be useful for athletes in those sports. Subject perceptions of the most appealing device features included its ability to train "the hips," to improve directional change movement quickness, the eccentric resistance mode, its ease in setting exercise range of motion and resistance levels using the touch screen, its ability to provide a total body workout in a relatively brief time period, the overall freedom of movement provided during exercise, and the need to stay mentally focused on each exercise repetition when using it.

Subject perceptions of the least appealing device features were the need to stay mentally focused on appropriate technique to minimize injury risk, slight discomfort regarding harness fit, and a longer learning curve than conventional exercise devices to become proficient in safe usage. Subject's perception of the athletic group that might benefit most by using the device included any athlete whose sport required controlled quick or explosive pivot directional changes, athletes who must use their hips for movement or stability, who must rely on their abdominal, low back, or core muscles such as martial arts competitors, gymnasts, wrestlers, volleyball, baseball, golf, boxing, or throwing sports athletes. Interestingly, several respondents also suggested that elderly individuals would also benefit through improved standing balance with device use at lower resistance and range of motion settings. Subject perceptions of individuals who would benefit the least only mentioned inactive elderly patients.

Discussion

While local ("knee-centric"), and regional (composite lower extremity) exercise training modes are essential to knee injury or re-injury prevention. However, athletic activities often demand sudden directional change movements. By improving coordination between the feet and core region, through the lower extremities, global (whole body) training may better prepare an athlete for the dynamic knee stability demands that occur during these movements. This is particularly important during single lower extremity jump landings that challenge frontal plane knee alignment with simultaneous upper extremity movements [6, 7] or when secondary capsuloligamentous knee stabilizers are compromised, such as following medial collateral ligament injury [18, 23, 24].

Of the 18 subjects who participated in this study, 9 were involved with competitive sports including soccer, volleyball, basketball, tennis, and swimming. The other nine subjects listed their primary sports/exercise activities as recreational running/jogging or weight training. Separate analysis of the competitive sports group revealed slightly greater values for perceived device use (7.9 ± 1.1) and for perceived usefulness for football, basketball, tennis, or soccer (8.4 ± 0.7). Overall subject perceptions of appealing device features, such as the ability to "train the hips," coincides with preliminary biomechanical test quantitative findings regarding the efficacy of the device to improve dynamic knee stability during single leg jump landings [19].

Interestingly, the need to remain focused while using the device was perceived to be a positive attribute by some subjects and a negative attribute by others. Independent analysis by sports activity group found that the competitive sports group perceived this to be a positive device attribute, while individuals whose athletic pursuits centered around recreational running, jogging, or weight training perceived this to be a negative device attribute. Several subjects commented that the "learning curve" to establish appropriate technique was longer using this device than while using conventional strength training modes. Our experience would confirm this, as it is essential for subjects who train on the device to understand appropriate movement patterns at low resistance settings prior to progressing to higher resistance and range of motion levels.

Cognitive linkage during functionally relevant movements may improve exercise program effects including enhanced self-efficacy to a greater extent than training simply to achieve rote strength, power, or endurance training goals [5, 9, 13, 27, 28]. Therefore, the perceived cognitive requirements needed to self-monitor Ground Force 360 Device use to insure safe and effective movements with the desired activation balance between core and lower extremity musculature might be a desirable entity. As with sports performance, where anterior cruciate ligament injury is often associated with an athlete performing a single lower extremity landing with minimal hip or knee flexion, with increased coxa varus-genu valgus [1], or with limited hamstring muscle group co-activation during quadriceps femoris activation [26], if the user assumes an upright stance position without appropriate hip and knee flexion against higher resistance levels or if they assume an upright stance while simply bending over at the waist during device operation, their chance of sustaining a low back or knee injury increases.

From both an evaluative and injury prevention training perspective, the Ground Force 360 Device appears to provide a useful environment for the rehabilitation clinician and client to interact as the client progresses through differing range of motion, resistance modes, and magnitudes during functionally relevant movements in agreement with the SAID principle of therapeutic exercise. The most common negative perception was occasional discomfort with device harness fit. Recent manufacturer modifications in harness design however have largely eliminated this concern. Most subjects also perceived the device to be useful for training controlled, quick or "explosive" pivot directional change movements. Since noncontact knee injuries in numerous sports are associated with these types of movements, a resistance training device that can effectively simulate these motions should prove to be a useful adjunct to traditional injury prevention training programs. The Ground Force 360 Device may provide a translational method of knee injury prevention training that helps bridge the gap between conventional strength-power training, functional conditioning activities, and actual sport performance.

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