The Impact of Power Training on Balance and Visual Feedback Removal

Liberty University

by

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Exercise Science: Pre-professional

Acceptance of Senior Honors Thesis

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Abstract

Because power training has been known to augment stability, the purpose of this study was to assess whether the removal of visual input affects lower limb muscle power production in young women who are resistance trained to the same degree it affects the untrained. This provided insight as far as the need for resistance training protocols in a largely untrained visually impaired population. To study this, fourteen college-aged female participants (18-23 years) performed a seated double-leg press on a leg sled machine, isolating power production of the lower limbs. After establishing baselines, which involved finding an average of power produced during five trials, the subjects were asked to close their eyes for the following set of five pushes. The power production was assessed by utilizing a Tendo Unit, with placement on one of the limbs of the machine, to measure power output during leg extension (measured in Watts). Statistics analyzed in SPSS determined the average power deficit of the athletic population to be 11.57 Watts, whereas the general population had an average power deficit of 37.43 Watts. The deficits experienced by each respective group upon visual removal were significantly different from one another, as evidenced by a p-value of .048. This accentuated the power-trained group's resilience. A suggested training plan regimen including cardiorespiratory, resistance, flexibility, and neuromotor exercises has been appended for persons experiencing visual impairment and seeking to better their balance through power.

The Impact of Power Training on Balance and Visual Feedback Removal

Those who are impaired visually are at a heightened risk of falling due to a compromised ability to detect spatial cues and recognize potentially hazardous environmental objects and situations (Legood, Scuffham, & Cryer, 2002). In the youthful subpopulation, falling can mean injury, temporary loss of independence, and perhaps time off work during recuperation. For the older, frail subpopulation of visually impaired persons, falling is associated with mortality, morbidity, reduced functionality, and premature nursing home admissions (Dionyssiotis, 2012). In either category, ensuring the greatest conceivable functionality for the blind and visually impaired is an important element in preventing unnecessary disability.

Falling, stumbling, and poor posture are considered “physical manifestations” displayed following the loss of the body’s most heavily relied on system of balance—the visual system (Gleeson, Sherrington, & Keay, 2014). However, the body is not rendered ineffective upon removal of visual input as the body utilizes *three* main systems of balance: the visual, vestibular, and somatosensory (often found in literature as “proprioceptive”) systems. It is the cerebellum and cerebral cortex that integrate information from all three systems to foster physical stabilization (Anson, Agada, Kiemel, & Jeka, 2014).

Most always, the systems work in tandem and produce behaviors favorable to an individual, though this is not always the case. Studying diseases like cerebellar ataxia and other conditions which create an inability to integrate systemic balance information can provide insight as to how the complex cerebellum functions. A person may experience similar disorientation due to cerebellar disconnect if sensory input from the visual, vestibular, and somatosensory systems conflict with one another (Han, Song, & Kim, 2011). For example, an individual operating a vehicle at a red light may believe the illusion that the car in front of him or her is rolling backwards, when in effect, the operator's own car is moving forward such that the somatosensory system was unable to detect the motion. With aid from contributors to the vestibular system, the sensory conflict may dissipate. Otherwise, the cerebral cortex might compel the person to glance to a fixed environmental point for visual assurance. In terms of stabilization, visual feedback is critical for determining balance as both strength and power contribute to postural integrity of the body (Alotaibi, Alghadir, Iqbal, & Anwer, 2016). For instance, low-vision adults exhibit greater body sway and poorer posture when compared to a normal vision group performing the same protocols (Tomomitsu, Alonso, Morimoto, Bobbio, & Greve, 2013).

The vestibular system contributes to balance as it is integral in constructing an "internal map" of one's center of mass in space with respect to gravity (Zalewski, 2015). This system is comprised of two labyrinths, the membranous labyrinth and the bony labyrinth (Santos, 2017), and it encodes linear and rotatory acceleration of the head. This signals to the brain head movement and position with respect to a constant gravitational acceleration (Pfeiffer, 2014). Therefore, the vestibular system is less individually relied on than the visual system for more simplistic actions such as walking, sitting, or standing. Working alongside vision, however, the vestibular response coordinates postural and ocular motor reflexes to maintain static and dynamic equilibrium and visual acuity during head movement (Zalewski, 2015).

The somatosensory system contributes to balance by integrating central nervous system input from the joints, ligaments, muscles, and tendons in the foot and lower leg. The skin houses proprioceptive receptors (mechanosensory neurons and stretch receptors) such as Pacinian corpuscles, Ruffini endings, unmyelinated nerve endings, Golgi tendon organs, and muscle spindles (Wang, et al., 2015). These transmit nerve impulses, initiating corresponding reflexes and motion controls vital for postural control. In an experiment aiming to greater comprehend the role of the somatosensory system, researchers isolated sensory receptors in the leg muscles. The study involved input removal of the feet and ankles by way of local anesthesia, and occluded blood flow through inflated pneumatic cuffs just above the ankles. With vestibular, visual and peripheral sensory inputs negated, it was determined that an involuntary response based on sensory input from the leg muscles was enough to provide stability despite perturbation (Fitzpatrick, Rogers, & McCloskey, 1994). This study predicted it is possible to augment balance without improving the visual or vestibular systems, as the somatosensory system was found to be capable of contributing to balance gains independently.

Though many years have passed since conduction of the aforementioned study, results are inconclusive as to what specifically is altered in the somatosensory system that affects balance (Smalley, White, & Burkard, 2018). Studies have shown that power training has been known to improve holistic balance of sighted individuals, but perhaps the element of power is the key to improving balance in the visually impaired population as well.

For clarification as to its implications, visual impairment is elucidated by the World Health Organization's (WHO, 2017) visual impairment and blindness fact sheet—the term "visual impairment" refers to anyone with moderate to severe vision impairment or blindness. It is understood those who are visually impaired often experience deficits in both power and strength and, further, that there is a relationship between visual impairment and reduced strength and stability when compared to sighted individuals (Blessing, 1993).

Strength differences between those visually impaired and those with sight may not be entirely attributable to loss of visual input, but rather the activity level of the individual. It is common for an individual in the visually impaired population to reduce physical activity upon onset of injury, leading to a loss of muscle power and deficiency in performance of daily activities (Lamoureux, Hassell, & Keeffe, 2004). However, though there is potential for strength and power deficits to be exacerbated by a lack of exercise, the fundamental issue remains: lost vision equates to lost power.

As strength and power are integral facets of stability, coupled with the knowledge that power training significantly improves balance in the general population (Orr, et al., 2006), an individual experiencing visual impairment may benefit from engaging in a power training routine—however, it is not yet clear to what degree the visual system of balance overlaps with the somatosensory system, and further, whether amplification of the somatosensory system through power training would prove to be effective without the visual field.

Power training for the blind and visually impaired *should* enhance overall power, aiding in stability, and resulting in less injury due to falling (Killebrew, Petrella, Jung, &

Hensarling, 2013). However, due to this lapse in research, it is unclear how vision relates to the somatosensory system, and how much power and therefore balance will be retained once the vision of participants is removed. If mechanosensory neurons and stretch receptors are significantly less effective upon visual removal, it would be an extraneous endeavor to power train visually impaired individuals who would not reap any benefits from this type of balance augmentation.

Subsequently, this study aims to discover whether lower-leg power production can be retained in the absence of vision. This will be investigated by utilizing the general population as the control group and power-trained athletes as the independent variable in order to better examine the effect of power training. Does removal of visual input affect lower limb muscle power production in young women who are resistance trained to the same degree it affects young women who are untrained? This study aims to determine if the power deficits experienced by each group are significantly different; if so, the findings may be extended to the understanding vision's role in the somatosensory system. It might also provide insight as far as the need for power training protocols in a largely untrained population. If the hypothesis were found to be correct, an individual suffering from visional difficulties should implement a power-training program to possibly experience greater balance, stability, and resistance to falls and resulting injury.

Methods

Subjects

Following institutional review board (IRB) approval, fourteen college-aged female participants (18-23 years) with no balance impairments were recruited to participate in this investigation. Group 1 consisted of seven NCAA scholarship athletes who had undergone at least three bouts of power training per week for the last six months. Group 2 consisted of seven healthy females with no current or prior resistance exercise involvement. All participants were thoroughly screened, ACSM risk-stratified, and placed into their respective categories. Certain potential subjects yielding ambiguous classification were not asked to participate in the study to avoid confounding data. In accordance with the IRB, the fourteen subjects were made aware of the purpose and the procedures of the study. The research study was voluntary. Written consent was obtained by all participants before testing. Their names and information have been kept confidential. The subjects were not compensated, but participation was incentivized by entering the subjects' initials into a private, electronic drawing for a 1 in 14 chance of winning a $10 Target gift card. The study included one testing overseer to record all data from the subjects to eliminate conduction discrepancies. Related IRB procedures including recruitment and consent documentation can be found in the appendix.

Materials

Equipment necessary for data conduction involved a Nebula seated leg sled machine set at a fixed one hundred pounds for all participants. The 45-degree leg press reclined at an angle such that the user could press the load upward in a diagonal direction.

A safety stop mechanism insured weight was unable to harm the user in the event the user pressed her load insufficiently. This Nebula machine was chosen for its functionality in test specificity and for its means of testing lower-leg power production safely.

A Tendo unit was required to measure power output during each repetition; the device was attached to the moving arm of the sled with the string parallel to the angle of the machine.

Figure 1. Nebula seated leg press machine with attached Tendo unit (Bouton, 2019).

Figure 2. Overhead view of equipment setup (Bouton, 2019).

Procedure

Testing took place in January of 2019 inside the Functional Assessment Lab (within Liberty University's Center for Natural Science). The subjects, arriving at staggered times to retain confidentiality, were asked to sign a consent form before participating in any activity. The subjects were then given a verbal explanation of how the Tendo unit worked—measuring power production by dividing 48 kilograms pressed by the time taken by the subject to go from full flexion of the legs to full extension. The subject was then permitted to gain cognizance of the motion by performing a brief warm-up of one to three reps. A two-minute rest break was then administered to remind the subject that she would be performing the first set of five repetitions with full vision, attempting to summon as much power as possible. The subjects' hands were instructed to remain on the handles and feet flat on the platform. The subjects then completed their first set of repetitions without vision input. Following the completion of the first set, the researcher explained that the following set would be without vision. The participants were requested to keep their eyes closed throughout the second set. The participants were encouraged to work as hard as they had in the previous repetitions. Once again, the researcher instructed the participants in the proper positioning before starting the repetitions. After a timed two-minute rest period, the subjects completed the second set of five repetitions and subsequently were thanked for their participation.

Results

The data recorded was an average of the five repetitions of power output (measured in Watts) before and after visual removal. Statistics in SPSS (Statistical Package for the Social Sciences) were performed to place the data into an operational format. A t-test was utilized to assess whether the mean power output deficit of the athletic population and the general population were statistically different from one another. Once compared on a quantitative level using a confidence interval of 95%, the groups were found to be statistically different. The average power deficit of the athletic population was found to be 11.57 Watts, whereas the general population had an average power deficit of 37.43 Watts. The general population demonstrated a much greater standard of deviation, with a resulting score of 23.09 compared to the athlete's 6.78. The p-value of the 2-tailed significance test revealed a score of .048.

Initials	vision	w/o vision	difference
GW	325	285	40
MS	276	262	4
SJ	233	202	31
AD	200	192	8
VM	204	170	34
KK	350	282	68
AR	334	270	64

Table 1. Outputs (measured in Watts) for nonathletic college-age females.

Initials	vision	w/o vision	difference
ND	356	355	12
GF	297	288	9
JL	312	301	11
JB	337	312	25
EL	230	222	8
DB	307	310	3
CN	367	360	33

Table 2. Outputs (measured in Watts) for power-trained college-age females.

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	NONATHS	37.4286	7	23.08576	8.72560
	ATHLETES	11.5714	7	6.77882	2.56215

Table 3. Results of “Paired Samples Statistics” from SPSS

		Paired Differences			
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower
Pair 1	NONATHS - ATHLETES	25.85714	27.53439	10.40702	.39208

Table 4. Results of “Paired Samples Test” from SPSS

		Paired Differences 95% Confidence Interval of the Difference Upper	t	df	Sig. (2-tailed)
Pair 1	NONATHS - ATHLETES	51.32221	2.485	6	.048

Table 5. Results of “Paired Samples Test” from SPSS

Discussion

An analysis of the results, specifically the yield of a p-value < .05, suggests that results were not due to chance. The difference in means reveals that the power deficit experienced by the athletic population was far less than general population, or in other words, the power-trained athletes retained more power. For the purposes of the study, an interpretation of the findings display it is statistically probable individuals who have undergone power strength and conditioning demonstrate a greater retention of power when vision is removed when compared to those individuals who have not undergone power strength and conditioning. A safe power-training program should therefore be implemented to any visually impaired persons, as training programs have proven in this study to attenuate the loss of power production. A retention of lower-leg power equates to retention in stability, thereby decreasing fall risk and permitting the greatest conceivable functionality for the blind and visually impaired.

Limitations of this study should be noted: to avoid confounding variables, this study only utilized a specific population. Therefore, the study should be repeated using populations of different ages and genders, with the paramount study assessing differing power deficit discrepancies between power-trained visually impaired athletes and the visually impaired general population. Another limitation of the study is a small sample size; findings may have included a lower p-value if there was more data to offset the outliers. A final limitation not accounted for was the learning element of the general population—many subjects in this study noted that they felt more comfortable as the test progressed, and the in the first trial, possible apprehension may have influenced their power output, or lack thereof, despite a warmup set. The test was designed to keep the subjects from experiencing fatigue, but inadvertently compromised comfortability of the untrained population. The power-trained population did not experience this limitation as all were familiar with the leg sled machine or similar equipment.

Another limitation is that for lack of access to such participants, the study did not assess participants who were legally blind. This was a simulated visual impairment, and therefore this study can only provide insight into the effects of visual impairment. It is recommended that future studies on this topic be performed with legally blind individuals to determine if the findings are legitimate.

Finally, this study can be used as theoretical framework for future research. The results of this study indicate that power training interventions could potentially be successful in protecting sighted individuals from strength reduction in a hazardous environment. While more specific research can be done to assess such circumstances, the information found in this study should be extended to individuals in a variety of contexts—including fire-fighters in smoke, a person removing his glasses in the gym or during a competition, or perhaps an elderly person closing his eyes in the shower or turning off the lights for bed at night—though further research should be done.

FITT-VP recommendations for adults with visual impairment

As visual impairment does not generally restrict the physical potential of the body, the following is the American College of Sports Medicine's (ACSM's) recommendation for augmented health and fitness tailored toward a visually impaired population with the goal of increasing lower-leg power production, as was determined to be effective. The recommendation includes progression from inactivity, as in many cases those with visual impairments tend to lead a sedentary lifestyle (Teutsch, 2016).

*Individuals must undergo a health screening prior to exercise to determine if other preexisting conditions contraindicate exercise.

**individuals must also consult their eye doctor as some eye conditions can be adversely affected by straining against weight.

	Cardiorespiratory Endurance	**Resistance Training**	**Flexibility**	**Neuromotor Exercise**
Frequency	5+ days/wk of moderate exercise, 3+ days/wk of vigorous exercise, OR a combination of the two	Each major muscle group, lower body priority, should be trained on 2-3 days/wk	2-3+ days/wk (daily most effective)	2-3+ days/wk
Intensity	Moderate and/or vigorous intensity recommended in most cases; light-to-moderate intensity would benefit previously sedentary individuals	40-50% 1-RM may be beneficial for improving strength in previously sedentary individuals; 75-85% 1-RM for experienced individuals to increase power	Stretch to the point of slight discomfort	No optimal intensity has been identified for effectiveness
Time	30-60 minutes of purposeful moderate exercise, 20-60 vigorous, or a combination of the two; less than 20 minutes for	No specific duration has been identified for effectiveness	Static stretch for 10-30 seconds	20-30+ minutes may be needed

	previously sedentary individuals			
Type	Regular, purposeful exercise that involves major muscle groups and is continuous and rhythmic in nature Ex: cycle ergometry, arm ergometry, treadmill with handrails, jump rope	Multi-joint exercises utilizing exercise equipment and/or bodyweight	A variety of stretch types are effective	Motor skill exercise
Volume	Target volume of 500-1000+ MET-min/wk	10-15 reps of 1-4 sets for inexperienced weightlifters; 3-5 sets of 3-5 reps for augmenting power	60 seconds of each flexibility exercise is a reasonable target	No optimal volume known
Pattern	One continuous session per day or multiple sessions of 10+ min; previously sedentary individuals may benefit from <10-minute bouts until able to tolerate longer intervals	2-3 minutes between each set of repetitions; 48+ hours between sessions for any single muscle group	Repetition of 2-4 times is recommended; warm muscles stretch more effectively	No optimal pattern known
Progression	A gradual progression of exercise volume by adjusting exercise duration, frequency, and/or intensity is reasonable until exercise goal (maintenance) is attained	A gradual progression of increased frequency or greater resistance is recommended	No optimal progression has been identified for effectiveness	No optimal progression known

Cardiorespiratory Endurance Training

Given the scientific evidence linking cardiorespiratory endurance and overall health, it is important not to overlook this fitness component when creating a program to augment stability.

Frequency

This refers to the number of days per week dedicated to cardiovascular endurance exercise. It is advisable to vary moderate and vigorous intensity where possible to increase benefits. Completing only vigorous exercise has been shown to increase the risk of physical injury.

Intensity

The overload principle of training states exercise below a minimum threshold will not challenge the body sufficiently to result in physiological advances. While many factors contribute to an individual's specific threshold, it can still be estimated. The following exercise classifications utilize three common methods to characterize the intensity of an individual's exercise session:

- Light exercise: 30-40% heart rate reserve (HRR), 6-11 rate of perceived exertion (RPE), able to sing
- Moderate exercise: 40-60% HRR, 12-14 RPE, able to talk
- Vigorous exercise: 60-90% HRR, 15-20 RPE, unable to carry a conversation

Intensities more specific to the individual can be determined by other formulaic methods:

- VO2R/VO2 method: VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$) = 58.443 - (0.215 · age) - (0.632 · BMI) - (68.639 · grade) + (1.579 · time)
- MET method: Relative VO2 / 3.5 ml/kgmin
- HR method: 206.9 – (0.67 X age), or (220 - age)

Time (Duration)

Exercise duration is described as a measure of the amount of time it takes to perform physical activity. Individuals should seek to accumulate 30-60 minutes of moderate exercise, 20-60 minutes of vigorous exercise, or as mentioned previously, a combination of the two. For weight management, or for those who come from previously sedentary backgrounds, longer durations of 60-90 minutes may be advantageous. Though more research is needed to confirm preliminary findings, exercise accumulation from bouts of 10 minutes each is thought to yield favorable adaptions for deconditioned individuals.

Type

Regular, purposeful, continuous, and rhythmic: all qualifications useful in improving cardiorespiratory fitness. Exercises including cycle ergometry, arm ergometry, treadmill with handrails, and jump rope are all tailored to the specific condition of the visually impaired individuals in that they follow the aforementioned mode of exercise and can be done in a safe and effective fashion.

Volume

Exercise volume, or quantity, is the product of frequency, intensity, and duration. Exercise volume can be used to estimate the energy expenditure as this relates to cardiorespiratory fitness. A target volume of 500-1000+ minutes of exercise is recommended. This is approximately equivalent to 1000 kcal/wk or 150 min/wk of moderate intensity exercise.

Progression

The rate of progression of an individual's exercise program depends on several factors including the individual's goals, fitness, and response to training. For the average visually impaired adult, initial progression should come from an increase in duration of exercise. Five to ten minute increases every one to two weeks for the first four to six weeks of a program is a reasonable method of progression. Following a month or greater of consistent exercise, the frequency and intensity may also be adjusted to better tailor a program to an individual's altering needs.

Resistance Exercise Training

In addition to augmenting stability through power training, resistance exercise is associated with "significantly better cardiometabolic risk factor profile, lower risk of all-cause mortality, fewer CVD events, lower risk of developing physical function limitations, and lower risk for nonfatal disease" (ACSM, 2013). It may also be effective in preventing and/or treating "metabolic syndrome" which is often experienced in inactive populations (Garber, 2011).

Examples of resistance activities to augment power include the use of free-weights, weight-lifting machines, resistance bands, plyometric activities, body weight exercises, and uphill running (Fleck, & Kraemer, 2014). Though these modes of exercise are strength bolstering, they can be used to augment power by adding the element of speed—power is the ability to rapidly exert a maximal force (Sapega, 1983). While both power and strength are required for daily function, power training has been found to be more effective than strength-training for improving physical function (Miszko, et al., 2003).

Frequency

For general muscular fitness, an individual with visual impairment should participate in a two to three day per week resistance program. All the major muscle groups should be trained, including the chest, shoulders, upper/lower back, abdomen, hips and legs. If possible, benefits are maximized if not all muscle groups are trained in each session, but rather split (Garber, 2011). Additionally, having a staggered resistance exercise provides more scheduling flexibility, improving adherence.

Type

Many types of resistance exercise can be performed: machine weights, free weights (once a visually impaired person is trained and a spotter is present), resistance band, etc. Multi-joint exercises stimulating both agonists and antagonists are recommended for all exercises; single joint exercises may also be included for specific goals but are not necessarily beneficial for the visual impaired population. Using different exercises to train the same muscle group may add variety and interest to a resistance exercise routine, thereby improving program adherence.

Lower body resistance exercise specifically correlates with increased stability, and therefore special emphasis should be placed on completing this type.

Volume

Inexperienced adults should start training each major muscle group by performing 10-15 reps of 1-4 sets. Experienced weightlifters would benefit from 3-5 sets of 3-5 reps for augmenting power. Each set may be derived from a combination of exercises, such as two sets of bench presses and two sets of dips for a total of four sets of shoulder exercises. A reasonable rest interval between sets is two to three minutes. This is not to be skipped—especially when power training.

Progression

The rate of progression of an individual's exercise program depends on several factors including the individual's goals, fitness, and training responses. Initial progression should come from amount of resistance, beginning with five to ten-pound increases while holding constant the sets, reps, and rest time constant. A transition toward power training (lower reps and sets, higher weight/intensity) should be the goal until maintenance is achieved.

Flexibility

Joint range of motion can be improved by engaging in flexibility exercises, which has been linked to a reduction of musculotendinous injuries, prevention of low back pain, and delayed muscle soreness (Garber, 2011). There is also evidence that postural stability and balance can be improved by engaging in flexibility, especially combined with resistance exercise, which is especially beneficial for a person with visual impairment.

Frequency

Following performance of flexibility exercises on more than two days per week, range of motion can improve chronically after three to four weeks—especially if performed daily.

Type

The following regions should all be addressed when stretching: shoulders, chest, neck, trunk, lower back, hips, anterior legs, posterior legs, and ankles.

Several types of flexibility exercises exist:

- Ballistic is a bouncing stretch using momentum of a moving body segment to produce the stretch, and it is often contraindicated as this motion triggers the stretch reflex
- Dynamic utilizes gradual transition from one stretch to another and involves repeating movements several times

- Static stretching can be active or passive and involves holding the stretch or having it held by a partner or object
- Proprioceptive neuromuscular facilitation (PNF) methods typically involve isometric action combined with a passive stretch

Volume

A combined total of 60 seconds per major joint utilizing any of the aforementioned techniques to the point of mild discomfort is advantageous for enhancing flexibility.

Neuromotor exercise

Often called “functional fitness training,” this type of exercise comprises motors skills involving balance, coordination, gait, and agility. It is often difficult to narrow this category as it is still being researched. To date, neuromotor exercise remains a broad category that is generally incorporated into an exercise regimen by adults with balance deficits. Definitive research is yet to be performed on the subject, thus limiting intensity, volume, pattern, and progression. What *has* been determined is motor exercise regimens of 20-30+ minutes in duration for more than 60 minutes a week have proven to be most effective in advancing agility and balance.

The two most popular, structed activities of neuromuscular exercise training are tai chi, yoga, and Pilates. Neuromotor training has, in some ways, gained credibility through published research on the effects of tai chi. One study observed relatively healthy community-dwelling older people participating in once per week tai chi classes for 16 weeks (Voukelatos, Cumming, Lord, & Rissel, 2007). Falls were less frequent in the tai chi group than in the control group, and the tai chi group demonstrated significantly greater stability on five of six balance tests.

Studies on the benefits of yoga yield similar results. Although further studies have yet to be conducted to determine whether yoga implementation can translate to fall prevention, yoga interventions have shown to cause slight improvements in balance and moderate improvements in mobility for adults over 60 (Youkhana, et al., 2015).

Additionally, Pilates implementation in dancers contributes to statistically significant improvements in alignment, body awareness, and core stability (Ahearn, Greene, & Lasner, 2018). Due to a limited amount of research, Pilates has yet to show significant balance gains for the general population; however, it is possible that the central facet of Pilates—core stability—is what contributes to balance, coordination, gait, and agility in all three of these neuromotor exercise types. Stability of the trunk is imperative for peak somatosensory system performance (Fitzpatrick, Rogers, & McCloskey, 1994), making safe, correctly performed core exercises a valuable addition to the exercise routine of someone experiencing visual impairment.

Summary

Three systems of balance contribute to the overall stability of the human body: the visual, the vestibular, and the somatosensory system. The brain's cerebellum and cerebral cortex integrate information from all three systems to attain premier physical stabilization yet weigh input from the visual system more heavily than input from the vestibular or somatosensory system. Though it is common for one system to influence how another system responds, research predicted the possibility of augmenting balance without improving the visual or vestibular systems once the somatosensory system was found to be capable of contributing to balance gains independently. Results are inconclusive as to what specifically is altered in the somatosensory system that affects balance, and whether attempt at amplification of the somatosensory system through power training, a known form of physical stabilization, would prove to be effective without the visual field. The author then tested power-trained athletes—those who had augmented their somatosensory system—against non-athletes to determine whether the athletes would have a similar or smaller power deficit upon visual removal. Seven college-aged female participants (18-23 years) from each of the two groups performed a seated double-leg press on a leg sled machine, isolating power production of the lower limbs. This involved one set of pushed with visual input, and the next without. The power production was assessed by a Tendo Unit, measuring power output during leg extension in Watts. The statistics were then analyzed in SPSS, determining the average power deficit of the athletic population to be 11.57 Watts, whereas the general population had an average power deficit of 37.43 Watts. The deficits experienced by each respective group upon visual removal were significantly different from one another, as evidenced by a p-value of .048. These findings exhibit it is statistically probable that individuals who have undergone power conditioning demonstrate a greater retention of power when vision is removed when compared to individuals who have not undergone power conditioning. A retention of lower-leg power equates to a retention of stability, thereby decreasing fall risk and permitting the greatest conceivable functionality for the blind and visually impaired. A safe power-training program should, therefore, be implemented to any visually impaired persons; one is included in this study. This suggested exercise program includes a holistic fitness plan involving cardiorespiratory, resistance, flexibility, and neuromotor exercises which have been appended for persons experiencing visual impairment with the goal of increasing lower-leg power production. The program discusses matters such as frequency of exercise, intensity level, duration, the type of exercise, volume, pattern, and lastly, progression from inactivity to the point where the somatosensory system of balance is improved.

References

Ahearn, E. L., Greene, A., & Lasner, A. (2018). Some effects of supplemental Pilates training on the posture, strength, and flexibility of dancers 17 to 22 years of age. *Journal of Dance Medicine & Science*, *22*(4), 192-202.

Alotaibi, A. Z., Alghadir, A., Iqbal, Z. A., & Anwer, S. (2016). Effect of absence of vision on posture. *Journal of Physical Therapy Science, 28*(4), 1374-1377.

Anson, E., Agada, P., Kiemel, T., & Jeka, J. (2014). Visual control of trunk translation and orientation during locomotion. *Experimental Brain Research*, *232*(6), 1954-1951.

Blessing, D.L. (1993). The effects of regular exercise programs for visually impaired and sighted schoolchildren. *Journal of Visual Impairment & Blindness*, 87, 50-52.

Bouton, J. (2019). Photographs of equipment. Reprinted with permission.

Dionyssiotis, Y. (2012). Analyzing the problem of falls among older people. *International Journal of General Medicine*, Advance online publication. http://doi.org/10.2147/IJGM.S32651

Fitzpatrick, R., Rogers, D. K., & McCloskey, D. I. (1994). Stable human standing with lower-limb muscle afferents providing the only sensory input. *The Journal of Physiology*, 480(2), 395–403.

Fleck, S. J., & Kraemer, W. J. (2014). *Designing Resistance Training Programs*. Champaign, IL: Human Kinetics.

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I., . . . Swain, D. P. (2011). Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in

Apparently Healthy Adults. *Medicine & Science in Sports & Exercise*, 43(7), 1334-1359.

Gleeson, M., Sherrington, C., & Keay, L. (2014). Exercise and physical training improve physical function in older adults with visual impairments but their effect on falls is unclear: A systematic review. *Journal of Physiotherapy*, *60*(3), 130-135. https://doi.org/10.1016/j.jphys.2014.06.010.

Killebrew, S. S., Petrella, J. K., Jung, A. P., & Hensarling, R. W. (2013). The effect of loss of visual input on muscle power in resistance trained and untrained young men and women. *Journal of Strength and Conditioning Research*, *27*(2), 495-500. doi:10.1519/jsc.0b013e3182577091

Han, B. I., Song, H. S., & Kim, J. S. (2011). Vestibular rehabilitation therapy: review of indications, mechanisms, and key exercises. *Journal of Clinical Neurology*, 7(4), 184-196.

Lamoureux, E. L., Hassell, J. B., & Keeffe J. E. (2004). The determinants of participation in activities of daily living in people with impaired vision. *American Journal of Ophthalmology*, *137*(2), 265-270. doi:10.1016/j.ajo.2003.08.003

Legood, R., Scuffham, P., & Cryer, C. (2002). Are we blind to injuries in the visually impaired? A review of the literature. *Injury Prevention*, *8*(2), 155-160.

Miszko, T. A., Cress, M. E., Slade, J. M., Covey, C. J., Agrawal, S. K., & Doerr, C. E. (2003). The effect of strength and power training on physical function in independent community-dwelling older adults. *Medicine & Science in Sports & Exercise*, *58*(2), 171-175.

doi:10.1097/00005768-200205001-01399

Orr, R., de Vos, N. J., Singh, N. A., Ross, D. A., Stavrinos, T. M., & Fiatarone-Singh M. A. (2006). Power training improves balance in healthy older adults. *The Journals of Gerontology: Series A*, *61*(1), 78–85. https://doi.org/10.1093/gerona/61.1.78

Pfeiffer, C., Serino, A., & Blanke, O. (2014). The vestibular system: a spatial reference for bodily self-consciousness. *Frontiers in Integrative Neuroscience*, 8(31)

Santos, C. F., Belinha, J., Gentil, F., Parente, M., Areias, B., & Jorge, R. N. (2017). Biomechanical Study of the Vestibular System of the Inner Ear Using a Numerical Method. *Procedia IUTAM*, 24, 30-37. doi:10.1016/j.piutam.2017.08.040

Sapega, A. A., & Drillings, G. (1983). The definition and assessment of muscular power. *Journal of Orthopaedic & Sports Physical Therapy*, *5*(1), 7-9.

Smalley, A., White, S. C., & Burkard, R. (2018). The effect of augmented somatosensory feedback on standing postural sway. *Gait & Posture*, 60, 76-80.

Teutsch, S. M., McCoy, M. A., Woodbury, R. B., & Welp, A. (2016). *Making eye health a population health imperative: Vision for tomorrow*. Washington, DC: The National Academies Press.

Tomomitsu, M. S. V., Alonso, A. C., Morimoto, E., Bobbio, T. G., & Greve, J. M. D. (2013). Static and dynamic postural control in low-vision and normal-vision adults. *Clinics*, *68*(4), 517–521. http://doi.org/10.6061/clinics/2013(04)13

Voukelatos, A., Cumming, R. G., Lord, S. R., & Rissel, C. (2007). A randomized, controlled trial of tai chi for the prevention of falls: the Central Sydney tai chi trial. *Journal of the American Geriatrics Society*, *55*(8), 1185-1191.

Wang, H., Ji, Z., Jiang, G., Liu, W., & Jiao, X. (2016). Correlation among proprioception, muscle strength, and balance. *Journal of Physical Therapy Science,* 28(12), 3468–3472. doi:10.1589/jpts.28.3468

WHO. (2017). Vision impairment and blindness fact sheet. *World Health Organization.*

Youkhana, S., Dean, C. M., Wolff, M., Sherrington, C., & Tiedemann, A. (2015). Yoga-based exercise improves balance and mobility in people aged 60 and over: a systematic review and meta-analysis. *Age and Ageing*, *45*(1), 21-29.

Zalewski C. K. (2015). Aging of the Human Vestibular System. *Seminars in Hearing,* 36(3), 175–196. doi:10.1055/s-0035-1555120

Appendix

CONSENT FORM—Nonathlete
The impact of power training on balance and visual feedback removal

Juliana Bouton
Liberty University
Department of Allied Health Professions

You are invited to be in a research study to better understand the correlation between power loss of athletic and non-athletic populations upon vision removal. You were selected as a possible participant because you are female, between the ages of 18 and 22, have *not* performed weight training on a regular basis in the past six months, and have expressed interest in participation. Please read this form and ask any questions you may have before agreeing to be in the study.

Juliana Bouton, a student in the Exercise Science program at Liberty University, is conducting this study.

Background Information: The purpose of this study is to investigate specifically the deficits of lower-leg power production as it pertains to stability.

Procedures: If you agree to be in this study, I would ask you to do the following things:

1. Watch/listen as a demonstration of how to use the double leg press machine is explained (1 minute)
2. Perform the leg press on a lower weight than trial weight to ensure understanding (1 minute)
3. Perform the leg press at trial weight around 90% 1RM (based on calculation) twice—once blindfolded, once without—with a two-minute rest interval in between
(3 minutes)

Risks: The risks involved in this study are minimal, which means they are equal to the risks you would encounter in everyday life. Due to the nature of the leg press machine, removal of vision will not impair stability, only power production.

Benefits: Benefits to society are long-term; by developing a correlation between weight training and decreased attenuation of power output upon vision removal, individuals concerned with stability or impaired vision may engage in an exercise program. These programs can positively impact and individual's health and overall well-being.

Participants should not expect to receive a direct benefit from taking part in this study.

Compensation: Participants will be entered in a raffle for a $10 Target gift card (with a one in twelve chance of winning). Email addresses will be requested for compensation purposes, however they will be pulled and separated from data collected to maintain anonymity.

Confidentiality: The records of this study will be kept private. In any sort of report published, included information will not make it possible to identify a subject as names will be removed permanently from the data once collection has been completed. Research records will be stored securely on a password-protected computer, and only the researcher will have access to the records. As per federal regulations, data will be retained for three years upon completion of the study and subsequently deleted. There will be no recording of audio or video whatsoever during the collection of data.

Voluntary Nature of the Study: Participation in this study is voluntary. Your decision whether to participate will not affect your current or future relations with Liberty University. If you decide to participate, you are free to withdraw at any time.

How to Withdraw from the Study: If you choose to withdraw from the study, please contact the researcher at the email address/phone number included in the next paragraph. Should you choose to withdraw, data collected from you will be destroyed immediately and will not be included in this study.

Contacts and Questions: The researcher conducting this study is Juliana Bouton. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at 940-595-0845, or at jbouton@liberty.edu. You may also contact the researcher's faculty chair, Jerry Pickard, at vpickard@liberty.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA 24515 or email at irb@liberty.edu.

Please notify the researcher if you would like a copy of this information for your records.

Statement of Consent: I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

____

Signature of Participant Date

____

Signature of Investigator Date

CONSENT FORM—Athlete
The impact of power training on balance and visual feedback removal

Juliana Bouton
Liberty University
Department of Allied Health Professions

You are invited to be in a research study to better understand the correlation between power loss of athletic and non-athletic populations upon vision removal. You were selected as a possible participant because you are female, between the ages of 18 and 22, have performed power training twice a week for the past six months, and have expressed interest in participation. Please read this form and ask any questions you may have before agreeing to be in the study.

Juliana Bouton, a student in the Exercise Science program at Liberty University, is conducting this study.

Background Information: The purpose of this study is to investigate specifically the deficits of lower leg power production as it pertains to stability.

Procedures: If you agree to be in this study, I would ask you to do the following things:

1. Watch/listen as a demonstration of how to use the double leg press machine is explained (1 minute)
2. Perform the leg press on a lower weight than trial weight to ensure understanding. (1 minute)
3. Perform the leg press at trial weight around 90% 1RM (based on calculation) twice—once blindfolded, once without—with a two-minute rest interval in between
   (3 minutes)

Risks: The risks involved in this study are minimal, which means they are equal to the risks you would encounter in everyday life. Due to the nature of the leg press machine, removal of vision will not impair stability, only power production.

Benefits: Benefits to society are long-term; by developing a correlation between weight training and decreased attenuation of power output upon vision removal, individuals concerned with stability or impaired vision may engage in an exercise program. These programs can positively impact and individual's health and overall well-being.

Participants should not expect to receive a direct benefit from taking part in this study.

Compensation: Participants will be entered in a raffle for a $10 Target gift card (with a one in twelve chance of winning). Email addresses will be requested for compensation purposes, however they will be pulled and separated from data collected to maintain anonymity.

Confidentiality: The records of this study will be kept private. In any sort of report published, included information will not make it possible to identify a subject as names will be removed permanently from the data once collection has been completed. Research records will be stored securely on a password-protected computer, and only the researcher will have access to the records. As per federal regulations, data will be retained for three years upon completion of the study and subsequently deleted. There will be no recording of audio or video whatsoever during the collection of data.

Voluntary Nature of the Study: Participation in this study is voluntary. Your decision whether to participate will not affect your current or future relations with Liberty University. If you decide to participate, you are free to withdraw at any time.

How to Withdraw from the Study: If you choose to withdraw from the study, please contact the researcher at the email address/phone number included in the next paragraph. Should you choose to withdraw, data collected from you will be destroyed immediately and will not be included in this study.

Contacts and Questions: The researcher conducting this study is Juliana Bouton. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at 940-595-0845, or at jbouton@liberty.edu. You may also contact the researcher's faculty chair, Jerry Pickard, at vpickard@liberty.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA 24515 or email at irb@liberty.edu.

Please notify the researcher if you would like a copy of this information for your records.

Statement of Consent: I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

____

Signature of Participant Date

____

Signature of Investigator Date

11/21/18

Dear student athlete:

As an Honors student in the Exercise Science Program at Liberty University, I am conducting research to better understand the correlation between power loss of athletic and non-athletic populations upon vision removal. The purpose of my research is to investigate specifically the deficits of lower-leg power production as it pertains to stability. I am writing to invite you to participate in my study.

If [BCA(E1]you are female, between the ages of 18 and 22, power train at least twice per week, and are willing to participate, you will be asked to perform two [BCA(E2]repetitions on a seated double leg press machine at around 90% 1RM (as determined by calculation)—once with full vision and once blindfolded. Including the time it takes to understand the procedures, give consent, and perform the leg presses, the process should take approximately 10 minutes total. Your name will be requested as part of your participation, but the information will remain confidential. The data, results, and interpretation will not include your name.

To participate, reply to this email to schedule a 10-minute appointment. A consent document will be provided for you to sign at the site of the research (Liberty's Human Performance Lab, which is on the lowest floor of the science building). Should you choose to decline participation upon the explanation of procedures or before/after signing the consent form, you are free to do so. Your name and any other information you provide will not be retained.

If you choose to participate, you will be entered in a raffle for a $10 Target gift card (with a one in twelve chance of winning).

Thank you for your time!

Sincerely,

Juliana Bouton
ACSM Certified Exercise Physiologist

11/21/18

Dear student:

As an Honors student in the Exercise Science Program at Liberty University, I am conducting research to better understand the correlation between power loss of athletic and non-athletic populations upon vision removal. The purpose of my research is to investigate specifically the deficits of lower-leg power production as it pertains to stability. I am writing to invite you to participate in my study.

If you are female, between the ages of 18 and 22, do not/have not performed weight training on a regular basis for the past six months, and are willing to participate, you will be asked to perform two repetitions around 90% of your 1RM on a seated double leg press machine—once with full vision and once blindfolded. Including the time it takes to understand the procedures, give consent, and perform the leg presses, the process should take approximately 10 minutes total. Your name will be requested as part of your participation, but the information will remain confidential. The data, results, and interpretation will not include your name.

To participate, reply to this email to schedule a 10-minute appointment. A consent document will be provided for you to sign at the site of the research (Liberty's Human Performance Lab, which is on the lowest floor of the science building). Should you choose to decline participation upon the explanation of procedures or before/after signing the consent form, you are free to do so. Your name and any other information you provide will not be retained.

If you choose to participate, you will be entered in a raffle for a $10 Target gift card (with a one in fourteen chance of winning).

Thank you for your time!

Sincerely,

Juliana Bouton
ACSM Certified Exercise Physiologist