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INJURY PREVENTION FOR TACTICAL PERSONNEL – COMPILING THE EVIDENCE AND LESSONS LEARNED

THE PROBLEM: TOO MANY INJURIES AT TOO HIGH A COST

Musculoskeletal injuries are the primary source of disability in the United States military (22). With 836,000 individuals affected by an injury in 2014, it is the single leading cause of medical encounters and missed work days (1). With an average cost of $3,000 per musculoskeletal injury, it totals $2.5 billion per year and has been estimated as high as $3.6 billion per year (4,23). In one study that randomly distributed surveys to military members, of the 10,692 respondents, 48.9% stated they were injured within the last year to the point they sought medical care, with strains and sprains accounting for more than 40% of all injuries (12). While the costs of injuries in local first responders are harder to calculate, the numbers are still staggering. One study estimating nearly 56,000 emergency room visits each year by police officers, 30% of which are due to sprains and strains alone (26). Finally, firefighters account for nearly 63,000 injuries yearly, with 27% due to "overexertion or strain" (13).

While this can be problematic stateside, it is also a burden in the deployed environment with more than 65,000 medical evacuations between 2001 – 2009 in Operations Iraqi and Enduring Freedom (7). However, 53,950 of these evacuations were from non-battle related musculoskeletal injuries (7). The annual cost to the Department of Veterans Affairs for musculoskeletal injury has increased 23 times since 2001, now exceeding $35.5 billion per year—more than the budget of the United States Marine Corps (16,17).

While the cost to American taxpayers is staggering, high injury rates also threaten military readiness and mission effectiveness. However, this cost is magnified in fire, emergency medical, and police personnel. Injured first responders not only put themselves and teammates at risk, but also place the general public at risk. While county commissioners, military commanders, and Surgeon Generals call for action, oftentimes little hands-on injury prevention programs make into policy. Therefore, strength and conditioning professionals (encompassing strength coaches, athletic trainers, and physical therapists) have an opportunity to make an impact on injury prevention.

The purpose of this article is two-fold: to briefly overview the evidence related to injury prevention in athletes, and to overview lessons learned in Air Force Special Tactics. A majority of evidence performed on injury prevention has been in the sports population. While there are frank differences between tactical personnel and the sports population, there are parallels as well. For instance, injury prevention research performed on soccer players may be applicable to an infantryman as both perform quick agility movements coupled with sprinting.

WHO IS AT RISK?

Reducing 840,000 yearly injuries in the military is a daunting task, so professionals should focus their attention on finding the population with the highest risk for injury and targeting those individuals first. For instance, it is known that athletes with decreased balance compared to their counterparts are seven times more at risk of injury (14). Those with a valgus force upon landing, previous history of injury, and those with poor neuromuscular control are also at greater risk of injury (10,20). Strength and conditioning professionals typically dwell on movement and its quality, however, other non-musculoskeletal factors should not be forgotten. This includes those with low Vitamin D, the biomechanical differences and higher injury risk of the female tactical athlete, as well as men and women who meet the definition of the relative energy deficiency in sport (RED-S) syndrome (8,18,24).

SCREENING INDIVIDUALS

For those professionals who have a small enough population to individually screen each athlete, screening has been called "essential to determine movement competency during the performance of fundamental movements," (2). Chimera published an overview of multiple screening methods of athletes in the *World Journal of Orthopedics* in 2016 of which the evidence will be summarized below (5).

FUNCTIONAL MOVEMENT SCREEN

The Functional Movement Screen (FMS™) currently has the largest amount of evidence in determining an athlete's risk of future injury. The populations tested range from the National Football League (NFL), National Basketball Association (NBA), National Collegiate Athletic Association (NCAA), soldiers, marines, coast guardsmen, police officers, and firefighters (10). The screen grades seven different movement patterns, and assigns a score from 0 – 3 points. Most studies outline that those who score less than 15 have a relative risk of injury between 2 – 6 times compared to those at or above 15. Corrective exercises, functional training programs, individual programs, and yoga can help raise FMS scores, but it is unknown if raising previously low FMS scores decreases the injury risk. Despite the plethora of evidence in regard to the validity and reliability of the FMS, recent systematic reviews with meta-analyses debate the injury predictability of this tool (3,15).

Y-BALANCE TEST

The Y-balance test has also been used to predict lower extremity injury risk in the NFL, NCAA, and military (5). With this test, the athlete reaches in three directions with either lower extremity or the upper extremity, and the average of three trials is normalized with limb length and compared side to side to assess asymmetries in reach distance. In the lower extremity, a normalized (composite) score of less than 94% or a difference in mean anterior reach asymmetry of at least four cm have been shown effective in predicting future injury. In fact, those with asymmetries at least four cm have relative risks of injury 2.3 – 3.7 times that of those under four cm (11,19). Unfortunately, the upper extremity stability test has not been studied in its relationship to future injury risk, but has been proven a valid and reliable tool to measure upper extremity and trunk strength asymmetries (28).

CLOSED KINETIC CHAIN UPPER EXTREMITY STABILITY TEST

As with the upper extremity Y-balance test, the closed kinetic chain upper extremity stability test (CKCUEST) is not only a valid and reliable test of trunk strength, but also upper extremity power (9). This test begins with men in the push-up position and women in a modified push-up position (i.e., on their knees) with their hands three feet apart marked by tape. In this test, the athlete moves the hands back and forth across the tape lines as many times as possible in 15 s. The test is repeated three times, averaged, and compared to normative data. As it is a measure of work per unit of time, power may also be calculated when incorporating body mass. While there is no evidence establishing its validity for assessing injury risk, professionals may view decreased power as an impairment to address. For instance, if a strength and conditioning professional has an athlete with a large upper extremity power requirement, the CKCUEST could be used to determine whether or not to address upper extremity power in the individual's strength and conditioning plan. More research is needed to assess this test's injury predictive capability.

JUMP TESTING

Finally, in screening, there are jump tests to assess how well an athlete jumps and lands. These tests include the following: drop jump, the landing error scoring system, and the tuck jump assessment (5). The drop jump assesses how well an athlete jumps after they step off and land from a box height of 31 cm. As the drop jump uses software analysis of video with markers placed on the athlete to measure valgus collapse, it has good reliability (5). However, this equipment and software is not available to all individuals and as such, the landing error score system can be used. In this test, an athlete is filmed from the frontal and sagittal plane and then scored on the quality of landing by a rater. While it also has good reliability (interclass correlation coefficient, or ICC) of .84 and .91 for inter-rater and intra-rater, respectively, only one of the two longitudinal studies noted a higher risk in anterior cruciate ligament (ACL) injuries in those with poor scores (5). Lastly, the tuck jump assessment is used to assess repeated jumping technique over 10 s. As this test exhibits high effort, the fatigue of proper mechanics can be assessed. It also has good intra-rater reliability with an ICC of .84, but has not been used to assess future risk of injury (5). However, strength and conditioning professionals may wish to use the test to assess for poor mechanics and where to direct their interventions.

TECHNOLOGY

Technological advances are also being assessed for their screening ability. For instance, the Dynamic Athletic Research Institute (DARI) Motion Platform system uses eight cameras to analyze many of the above tests as well as generalized range of motion and kinematics over a 10-min screening process. Once complete, it uses computer algorithms to interpret the data, provide a generalized risk assessment of athletes and teams, and provides individualized corrective exercises in an attempt to mitigate that risk (6). Evidence assessing its validity to assess injury risk is currently underway. While this may soon be a gold standard, the current cost of each unit may limit availability for use among tactical populations. Other wearable technological advances provide real-time data which can be used to assess workload, heart rate, the percentage of estimated VO_2max, athlete recovery, and even estimated core temperature. These data can then be used immediately to remove an at-risk individual from the event. For instance, a tactical facilitator could see an estimated core body temperature of 105° F and assess the individual for heat exhaustion or heat stroke. However, despite the advances in technology, screening or monitoring a large or dispersed population is a difficult task, and the use of pre-built injury prevention programs is most appropriate.

INJURY PREVENTION PROGRAMS

There are many pre-built injury prevention programs that have been shown to be effective. At Travis Air Force Base, a pre-built warm-up program utilizing FMS correctives, dynamic planking, and agility was implemented among pilots between 20 – 40 years old. The results demonstrated the intervention was effective in decreasing injuries by 50% (23). This led to increased unit readiness and decreased operations tempo as more personnel were able to fly missions.

Another pre-built warm-up called the "Fédération International de Football Association (FIFA) 11," focuses on generalized potentiation of muscle groups, proper landing mechanics, planking, eccentrics, and agility. It has been shown to decrease injuries in soccer by 39% (25). Also, the addition of eccentric exercises has proven not only good for rehabilitation in recovering from an injury, but also in the prevention of injury. For instance, the Nordic hamstring exercise has strong evidence in decreasing hamstring strain risk (27). Finally, high-intensity neuromuscular control programs that focus on potentiation of muscle groups, proper landing and sprinting mechanics, recovering quickly from the ground, and agility have all been proven effective in decreasing injury (21).

LESSONS LEARNED FROM AIR FORCE SPECIAL TACTICS

The programs and screenings discussed above have been applied to the special tactics training pipeline. In doing so, lessons have been learned when attempting to reduce injury when the physical demands of special tactics coursework is not always optimal for strength or conditioning.

First, education of the athlete is essential. While it is important to educate everyone on the "why we do what we do," it is particularly vital for the newer generation hoping to become operators. After a three-day formal education course was implemented, there has been an improvement in corrective exercise compliance, quality of individual warm-ups, pass rates at our location and the next location, and improved physical evaluation scores. This three-day course focuses on nutrition, stress education, warm-up, cool-down, pain neuroscience, and other lectures.

Second, it is imperative to monitor training loads and demands of the course (e.g., rucking, moving heavy items, combatives, etc.) with the workload and demands of the strength and conditioning program. However, due to weather, change in course material, or even mission planning, these workloads can change as soon as five minutes before the training mission occurs. Therefore, strength and conditioning professionals should be familiar with daily undulating periodization and be able to apply it daily to avoid overtraining, poor tracking of workloads, and possibly causing injury to the athlete.

Thirdly, while there is evidence that FMS scores of 14 or less are predictive of injury, statistical analysis has been unable to determine a cutoff value at this location, nor would one cutoff score be potentially valid across different sports or populations. This may be due to providing corrective exercise, thus lowering the trainee's injury risk—which is not performed in validation studies. While we have continued the FMS to target individual correctives for each person, we have considered stopping this screening method due to most individuals having the same impairments and poor quality of movement. As such, we may simply incorporate the correctives into the warm-up routine.

Lastly, while tracking the number of injuries can be easy, caution should be used to ensure it is the appropriate variable to assess. For instance, the number of injuries in a unit may increase as a physical therapist or athletic trainer moves to that unit which previously did not have one. As access to care has increased, more athletes come forward with both large and minor problems. In fact, in one of the Battlefield Airmen pipelines, over 85% of trainees stated that they would not have sought care for their injury if there was not a physical therapist assigned to their unit. Instead, focusing on the number of missed work days, mobility restrictions, missed training days, attrition (graduation rates) from training programs, and days on "Duties not Including Flying" for military personnel may be most advantageous. Civilians have the added capabilities to track workers' compensation claims, cost of funding temp-hires to backfill positions, overtime pay, and overexertion claims.

CONCLUSION

There are many ways for tactical strength and conditioning professionals to help reduce injury risk. While there is a plethora of evidence available, readers are encouraged to try a wide range of screening techniques and pre-built programs to pick and choose what works best for their population. For our location, we noted that education and tailoring training to loads have shown a 40% decrease in those who fail the final physical evaluation by and an 80% decrease in the need to remove trainees from the course due to injury. While we have had moderate success at our location, more data-based evidence is needed to assess these techniques' effectiveness on graduation rates throughout two-years of special operations training at a variety of locations throughout the country.

REFERENCES

1. Armed Forces Health Surveillance Branch. Absolute and Relative Morbidity Burdens Attributable to Various Illnesses and Injuries, Active Component, U.S. Armed Forces. *Medical Surveillance Monthly Report* 25(5): 2-9, 2018.

2. Bird, SP, and Markwick, WJ. Musculoskeletal screening and functional testing: Considerations for basketball athletes. International *Journal of Sports Physical Therapy* 11(5): 784-802, 2016.

3. Bonazza, NA, Smuin, D, Onk, CA, Silvis, ML, and Dhawan, A. Reliability, validity, and injury predictive value of the Functional Movement Screen: A systematic review and meta-analysis. *American Journal of Sports Medicine* 45(3): 725-732, 2017.

4. Bulzacchelli, M, Sulsky, S, Zhu, L, Brandt, S, and Barenberg, A. The cost of basic combat training injuries in the U.S. Army: Injury-related medical care and risk factors. Final Technical Report. Military Performance Division, U.S. Army Research Institute of Environmental Medicine. 2017.

5. Chimera, N, and Warren, M. Use of clinical movement screening tests to predict injury in sport. *World Journal of Orthopedics* 7(4): 202-217, 2016.

6. Colyer, SL, Evans, M, Cosker, DP, and Salo, AIT. A review of the evolution of vision-based motion analysis and the integration of advanced computer vision methods towards developing a markerless system. *Sports Medicine Open* 5; 4(1): 24, 2018.

7. Cubano, M. *Aeromedical Evacuation. Emergency War Surgery.* Fort Sam Houston, TX: Borden Institute; 47-59, 2013.

8. Dao, D, Sodhi, S, Tabasinejad, R, Peterson, D, Ayeni, OR, Bhandari, M, and Farrokhyar, F. Serum 25-Hydroxyvitamin D levels and stress fractures in military personnel: A systematic review and meta-analysis. *The American Journal of Sports Medicine* 43(8): 2064-2072, 2015.

9. de Oliveira, V, Pitangui, A, Nascimento, V, da Silva, H, Dos Passos, M, and de Araújo, R. Test-retest reliability of the closed kinetic chain upper extremity stability test (CKCUEST) in adolescents: Reliability of CKCUEST in adolescents. *International Journal of Sports Physical Therapy* 12(1): 125-132, 2017.

10. Dorrel, B, Long, T, Shaffer, S, and Myer, G. Evaluation of the Functional Movement Screen as an injury prediction tool among active adult populations: A systematic review and meta-analysis. *Sports Health* 7(6): 532-537, 2015.

11. Gonell, AC, Romero, JA, and Soler, LM. Relationship between the y balance test scores and soft tissue injury incidence in a soccer team. *International Journal of Sports Physical Therapy* 10(7): 955-66, 2015.

12. Hauret, KG, Bedno S, Loringer K, Kao TC, Mallon T, and Jones BH. Epidemiology of exercise- and sports-related injuries in a population of young, physically active adults: A survey of military servicemembers. *The American Journal of Sports Medicine* 43(11): 2645-2653, 2015.

13. Haynes, H. NFPA report - Firefighter injuries in the United States. Retrieved July 9, 2018, from https://www.nfpa.org/News-and-Research/Fire-statistics-and-reports/Fire-statistics/The-fire-service/Fatalities-and-injuries/Firefighter-injuries-in-the-United-States.

14. McGuine, T. Sports injuries in high school athletes: A review of injury-risk and injury-prevention research. *Clinical Journal of Sport Medicine* 16(6): 488-499, 2006.

15. Moran, RW, Schneiders, AG, Mason, J, and Sullivan, SJ. Do Functional Movement Screen (FMS) composite scores predict subsequent injury? A systematic review with meta-analysis. *British Journal of Sports Medicine* 51(23): 1661-1669, 2017.

16. Office of Public Health, Department of Veterans Affairs. Analysis of VA Health Care Utilization among Operation Enduring Freedom (OEF), Operation Iraqi Freedom (OIF), and Operation New Dawn (OND) Veterans. June, 2015.

17. Office of the Under Secretary of Defense (Comptroller). National Defense Budget Estimates for FY 2015. April, 2014.

18. Otsuki, R, Kuramochi, R, and Fukubayashi, T. Effect of injury prevention training on knee mechanics in female adolescents during puberty. *International Journal of Sports Physical Therapy* 9(2): 149-156, 2014.

19. Plisky, PJ, Rauh, MJ, Kaminski, TW, and Underwood, FB. Star excursion balance test as a predictor of lower extremity injury in high school basketball players. *Journal of Orthopaedic and Sports Physical Therapy* 36(12): 911-919, 2006.

20. Renstrom, P, Ljungqvist, A, Arendt, E, Beynnon, B, Fukubayashi, T, Garrett, W, et al. Non-contact ACL injuries in female athletes: An International Olympic Committee current concepts statement. *British Journal of Sports Medicine* 42(6): 394-412, 2008.

21. Richmond, S, Kang, J, Doyle-Baker, P, Nettel-Aguirre, A, and Emery, C. A school-based injury prevention program to reduce sport injury risk and improve healthy outcomes in youth: A pilot cluster-randomized controlled trial. *Clinical Journal of Sport Medicine* 26(4): 291-298, 2016.

22. Roy, TC. Diagnoses and mechanisms of musculoskeletal injuries in an infantry brigade combat team deployed to Afghanistan evaluated by the brigade physical therapist. *Military Medicine* 176(8): 903-908, 2011.

23. Shumway, J, Anderson, D, and Bishop, B. Effectiveness of an injury prevention warm-up for unit physical training: A case series of two flying squadrons. *Military Medicine* 181(5 Suppl): 95-103, 2016.

24. Tenforde, A, Barrack, M, Nattiv, A, and Fredericson, M. Parallels with the female athlete triad in male athletes. *Sports Medicine (Auckland, N.Z.)* 46(2): 171-182, 2016.

25. Thorborg, K, Krommes, K, Esteve, E, Clausen, M, Bartels, E, and Rathleff, M. Effect of specific exercise-based football injury prevention programmes on the overall injury rate in football: A systematic review and meta-analysis of the FIFA 11 and 11+ programmes. *British Journal of Sports Medicine* 51(7): 562-571, 2017.

26. Tiesman, H, Gwilliam, M, Konda, S, Rojek, J, and Marsh, S. Nonfatal injuries to law enforcement officers: A rise in assaults. *American Journal of Preventive Medicine* 54(4): 503-509, 2018.

27. van der Horst, N, Smits, D, Petersen, J, Goedhart, E, and Backx, F. The preventive effect of the Nordic hamstring exercise on hamstring injuries in amateur soccer players: a randomized controlled trial. *The American Journal of Sports Medicine* 43(6): 1316-1323, 2015.

28. Westrick, RB, Miller, JM, Carow, SD, and Gerber, JP. Exploration of the y-balance test for assessment of upper quarter closed kinetic chain performance. *International Journal of Sports Physical Therapy* 7(2): 139-147, 2015.

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