Journal of Bodywork and Movement Therapies (2006) 10, 154–158

ELSEVIER

Journal of
Bodywork and
Movement Therapies

www.intl.elsevierhealth.com/journals/jbmt

SELF MANAGEMENT: CLINICIAN SECTION

Functional training for performance enhancement—Part 1: The basics ☆

Craig Liebenson, DC*

10474 Santa Monica Blvd., No. 202, Los Angeles, CA 90025, USA

Introduction

How can we make training as functional as possible so it will stabilize an athlete and enhance performance in their sports activities? Functional stability training is goal oriented. Floor or isotonic-machine based exercise may be used as stepping stones to isolate and "groove" stability patterns. However, as soon as possible "core" stability must be trained in sport-specific ways.

The sooner in the program actual functional activities are trained the better. But, it is necessary at each step that the movement is in the patients functional range (FR). The FR is the range in which there is minimal mechanical sensitivity (MS) or abnormal motor control (AMC).

Unless functional training occurs there is no guarantee that the individual will be stable during the challenges of elite sporting competition (Rutherford, 1988). Examples of functional training include squats, lunges, pushing, pulling, catching, carrying, etc. Stability patterns may be further challenged by the addition of unstable surfaces such as balance boards and gymnastic balls. This provides enhanced proprioceptive stimulation which facilitates motor learning. However, the addition of an unstable surface is not recommended unless the athlete maintains good motor control during the training. For instance if the introduction of an unstable surface causes loss of neutral joint position (e.g. subtalar hyperpronation, valgus knee angle, lumbar kyphosis, head forward posture, etc.) the training should be modified.

Reactivation progressions should continue until the athlete's FR includes their sports activity (see Fig. 1). Athletes will require high-level performance training which will also include strength/power, agility, and speed challenges. These would be superimposed on training tissue sparing strategies to reduce exposure to mechanisms of injury and tissue stabilizing strategies to "groove" appropriate movement patterns. A frequent training error in programs designed for highly fit individuals is the performance of trunk or spine exercises with high-level strength, balance, or agility demands, without proper motor control. A step-wise approach built upon a foundation of conscious-kinaesthetic awareness of appropriate motor control is the best guarantee of injury prevention when performing high-level activities with a narrow safety/stability margin (O'Sullivan, 2000).

Load sharing and tissue sparing

A key concept for joint stability is load sharing. The hip joints are designed to handle high loads. The deep acetabulum and large surrounding musculature are capable of supporting these forces. However, if hip joint mobility is compromised,

☆This paper may be photocopied for educational use.

*Tel.: +1 310 470 2909; fax: +1 310 470 3286.
E-mail address: cldc@flash.net.

1360-8592/$ - see front matter © 2006 Published by Elsevier Ltd.
doi:10.1016/j.jbmt.2006.01.003

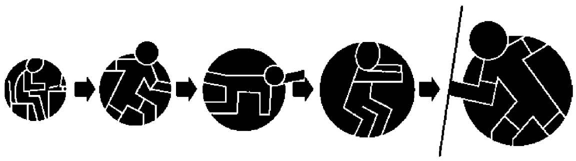

Figure 1 The Reactivation Continuum. Reprinted with permission from Liebenson C. Functional Stability Training in Liebenson C (ed) Rehabilitation of the Spine: A Practitioner's Manual (2nd ed). Lippincott/Williams & Wilkins, Baltimore, 2006.

loads may transfer to the next available motion segment, typically the lumbar spine. It has been shown that decreased passive hip extension mobility is related to low back pain (LBP) (Kujala et al., 1994; McGill et al., 2003) as is decreased hip internal rotation (Cibulka et al., 1998; Ellison et al., 1990). Preliminary data from McGill et al. (2003) suggest that decreased hip extension mobility may be predictive of disabling LBP. Van Dillen et al. (2000) reported that chronic LBP subjects had less passive hip extension mobility than asymptomatic subjects. Studies in adolescents have documented that future episodes of LBP are correlated with decreased hip extension range of motion (ROM) (Kujala et al., 1994).

Poor control of valgus loading of the knee predicts non-traumatic knee injuries in female athletes (Hewett et al., 2005a; McLean et al., 2005). Female athletes with increased dynamic valgus and high abduction loads are at increased risk of anterior cruciate ligament (ACL) injury (Hewett et al., 2005a). Reducing injury rates thus relies on detecting and continually evaluating people with relatively large valgus motions (McLean et al., 2005). Side step and side jump analysis of the knee valgus angle in the frontal plane were demonstrated to be valid measures.

A comparison of male and female healthy collegiate soccer players demonstrated that females experience increased frontal plane moments and decreased sagittal plane moments during early deceleration of side-stepping manoeuvres (Sigward and Powers, 2006). This dysfunction in tissue sparing of the knee was termed an "at risk" pattern in that decreased frontal plane support of the knee could overload the ACL. It was also noted that the females exhibited increased quadriceps activity and smaller net flexor moments suggesting less sagittal plane protection (i.e. increased tendency towards anterior tibial translation).

Children under 7 years of age have been shown to have a predisposition to faulty motor control—in particular, hyperprontation—in the foot and ankle during gait (Ganley and Powers, 2005). It is suggested that prepubertal or early pubertal female athletes may benefit from biomechanical optimization by reducing their future lower extremity injury risk (Hewett et al., 2005b).

Muscle imbalance and joint stability

Nadler et al. (2000, 2001) demonstrated that hip muscle imbalance is associated both retrospectively and prospectively with LBP in female athletes. In particular, asymmetric *hip extensor strength* was significantly correlated with LBP incidence. Those with LBP had a 15% strength imbalance compared with only a 5.3% imbalance in those without LBP. This same asymmetry was not found in male athletes, but it is interesting to note that National Collegiate Athletic Association Injury Surveillance Data from 1997 to 1998 showed that female athletes were almost twice as likely as males to develop LBP (National Collegiate 1997–1998). Other consistent findings include increased fatigability of the gluteus maximus in individuals with chronic LBP (Kankaapaa et al., 1998; Leinonen et al., 2000). Vogt and Banzer (1997) and Vogt et al. (2003) found that reduced active hip extension (Janda's test) ROM and delayed relaxation of the gluteus maximus and lumbar erector spinae muscles can distinguish between back pain subjects and asymptomatic individuals. Similarly, delayed relaxation of trunk agonist and antagonist muscles during functional tasks has been shown to distinguish LBP individuals from asymptomatic people (Cholewicki et al., 2000).

Females have been shown to utilize different muscular activation patterns compared to males (i.e. decreased gluteus maximus and increased rectus femoris muscle activity) during landing maneuvers (Zazulak et al., 2005). Decreased hip muscle activity and increased quadriceps activity were concluded to be likely contributors to the increased susceptibility of female athletes to non-contact ACL injuries.

A positive active straight leg raise (hip flexion) has been shown to be associated with sacroiliac (SI) pain (Mens et al., 2001, 2002). It has been shown that altered kinematics of the diaphragm and pelvic floor are present in those with a positive test (O'Sullivan et al., 2002).

Mascal et al. have demonstrated that a pelvic drop and excessive knee valgus during a step down task is indicative of gluteus medius weakness (Mascal et al., 2003). Ireland et al. has showed this weakness is common in patients with knee pain (Ireland, 2004). Specifically, deficits of 26% in hip abduction strength and 36% in hip external rotation strength were found.

Functional training

Neuromuscular training has been shown to improve performance and lower-extremity biomechanics in female athletes (Hewett et al., 2002; Myer et al., 2005; Paterno et al., 2004). Hewett et al. (1999) has shown in female collegiate athletes that the introduction of supinatory training during plyometric squats prospectively reduced the incidence of injury in the coming season. The four main components of this training are plyometric and movement, core strengthening and balance, resistance training, and speed training (Myer et al., 2005).

Gary Gray has pioneered exercises such as balance reaches incorporating the Star Matrix (Gray, 2001; Risberg et al., 2001; Liebenson, 2002a, b, 2003a, b, 2006; McGill, 2006). By balancing or supporting on one limb while reaching at different angles with the other limb tri-planer movement in the sagittal, frontal, and transverse planes can be trained. By adding upper quarter movements to the activity, functional activities involving pushing and pulling such as tennis, baseball, golf, bowling, etc. can be facilitated.

If the goal of training is to improve motor control then one set of 8–10 repetitions, twice daily of sub-threshold exercises is needed. However, to build strength, power, and speed, 3–5 sets of exercise at threshold 3–4 times/week is preferred. Following the Russian reverse pyramid approach since each set is to threshold, it is important to reduce the repetitions with each subsequent set in order to maintain form or motor control (McGill, 2006). Remember, as Aristotle said "practice does not make perfect, it makes permanent."

Sample functional and performance exercises

Illustrations of each the following exercise are shown in the accompanying Self-Care articles.

1. Supported functional reach
   Purpose:
   - Activate gluteus maximus and quadriceps
   - Dynamically stretch posterior hip capsule

   Signs of AMC:
   - Bending at the waist without flexing the support leg's knee
   - Gripping too hard
2. Functional (balance) reach
   Purpose:
   - Activate gluteus maximus (6:00) and gluteus medius (5:00 or 7:00)
   - Groove control of the patello-femoral joint during loaded activities

   Signs of AMC:
   - Trendelenberg position
   - Unlevel hips or shoulders
   - Loss of balance
   - Anterior movement of knee beyond the toes
   - Medial collapse of knee
3. Functional (balance) reach with ball
   Purpose:
   - Activate gluteus medius to control frontal plane instabilities

   Signs of AMC:
   - Inability to keep the support leg vertical
   - Medial collapse of the knee (excessive valgosity)
   - Subtalar hyperpronation
   - Unlevel hips or shoulders
4. Plyometric side step
   Purpose:
   - Speed, power and endurance training of the gluteus maximus/medius and quadriceps

   Signs of AMC:
   - Inability to jump dynamically
   - Lumbar kyphosis
   - Trunk rotation
   - Unleveling of the shoulders
5. Lateral squat
   Purpose:
   - Activate gluteus maximus and quadriceps while stretching ipsilateral posterior hip capsule and contralateral thigh adductors

   Signs of AMC:
   - Inability to keep the knee over the foot
   - Failure to feel a stretch in the posterior hip capsule of the stepping leg
   - Unlevel hips or shoulders
6. Lunge dip
   Purpose:
   - Power and endurance training of the quadriceps, gluteus maximus and soleus while stretching the posterior hip capsule on the support leg and psoas on the other leg

   Signs of AMC:
   - Not using a stick or bar to comfortably find the right initial position
   - Not keeping the knee over the foot (laces)
   - Trunk flexion

References

Cholewicki, J., Simons, A.P.D., Radebold, A., 2000. Effects of external loads on lumbar spine stability. Journal of Biomechanics 33, 1377–1385.

Cibulka, M.T., Sinacore, D.R., Cromer, G.S., Delitto, A., 1998. Unilateral hip rotation range of motion asymmetry in patients with sacroiliac joint regional pain. Spine 23, 1009–1015.

Ellison, J.B., Rose, S.J., Sahrmann, S.A., 1990. Patterns of rotation range of motion: a comparison between healthy subjects and patients with low back pain. Physical Therapy 70, 537–541.

Ganley, K.J., Powers, C.M., 2005. Gait kinematics and kinetics of 7-year-old children: a comparison to adults using age-specific anthropometric data. Gait Posture 21 (2), 141–145.

Gray, G., 2001. Total Body Functional Profile. Wynn Marketing, Adrian MI.

Hewett, T., Lindenfeld, T.N., Roccobene, J.V., Noyes, F.R., 1999. The effect of neuromuscular training on the incidence of knee injury in female athletes: a prospective study. American Journal of Sports Medicine 27, 699–706.

Hewett, T.E., Paterno, M.V., Myer, G.D., 2002. Strategies for enhancing proprioception and neuromuscular control of the knee. Clinical Orthopaedics and Related Research 402, 76–94.

Hewett, T.E., Myer, G.D., Ford, K.R., Heidt Jr., R.S., Colosimo, A.J., McLean, S.G., van den Bogert, A.J., Paterno, M.V., Succop, P., 2005a. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study. American Journal of Sports Medicine 33 (4), 492–501.

Hewett, T.E., Myer, G.D., Ford, K.R., 2005b. Reducing knee and anterior cruciate ligament injuries among female athletes: a systematic review of neuromuscular training interventions. Journal of Knee Surgery 18 (1), 82–88.

Ireland, M.L., WIllson, J.D., Ballantyne, B.T., McClay Davis, I., 2004. Hip strength in females with and without patellofemoral pain. Journal of Orthopaedic & Sports Physical Therapy 33, 671–676.

Kankaapaa, M., Taimela, S., Laaksonen, D., et al., 1998. Back and hip extensor fatigability in chronic low back pain patients and controls. Archives of Physical Medicine and Rehabilitation 79, 412–417.

Kujala, U.M., Taimela, S., Salminen, J.J., Oksanen, A., 1994. Baseline arthropometry, flexibility and strength characteristics and future low-back-pain in adolescent athletes and nonathletes. A prospective, one-year, follow-up study. Scandinavian Journal of Medicine & Science in Sports 4, 200–205.

Leinonen, V., Kankaanpaa, M., Airaksinen, O., et al., 2000. Back and hip flexion/extension: effects of low back pain and rehabilitation. Archives of Physical Medicine and Rehabilitation 81, 32–37.

Liebenson, C.S., 2002a. Advice for the clinician and patient: functional exercises. Journal of Bodywork and Movement Therapies 6 (2), 108–116.

Liebenson, C.S., 2002b. Advice for the clinician and patient: functional training part one: new advances. Journal of Bodywork and Movement Therapies 6 (4), 248–253.

Liebenson, C.S., 2003a. Advice for the clinician and patient: functional training part two: integrating functional training into clinical practice. Journal of Bodywork and Movement Therapies 7 (1), 20–24.

Liebenson, C.S., 2003b. Advice for the clinician and patient: functional training part three: transverse plane facilitation. Journal of Bodywork and Movement Therapies 7 (2), 97–103.

Liebenson, C., 2006. Functional stability training. In: Liebenson, C. (Ed.), Rehabilitation of the Spine: A Practitioner's Manual, second ed. Lippincott/Williams & Wilkins, Baltimore.

Mascal, C.L., Landel, R., Powers, C., 2003. Management of patellofemoral pain targeting hip, pelvis, and trunk muscle function: 2 case reports. Journal of Orthopaedic & Sports Physical Therapy 33, 647–660.

McGill, S.M., 2006. Ultimate Back Fitness and Performance, second ed. Wabunu.

McGill, S., Grenier, S., Bluhm, M., Preuss, R., Brown, S., Russell, C., 2003. Previous history of LBP with work loss is related to lingering deficits in biomechanical, physiological, personal, psychosocial and motor control characteristics. Ergonomics 46, 731–746.

McLean, S.G., Walker, K., Ford, K.R., Myer, G.D., Hewett, T.E., van den Bogert, A.J., 2005. Evaluation of a two dimensional analysis method as a screening and evaluation tool for anterior cruciate ligament injury. British Journal of Sports Medicine 39 (6), 355–362.

Mens, J.M., Vleeming, A., Snijders, C.J., et al., 2001. Reliability and validity of the active straight leg raise test in posterior pelvic pain since pregnancy. Spine 26, 1167–1171.

Mens, J.M., Vleeming, A., Snijders, C.J., et al., 2002. Validity of the active straight leg raise test to measure disease severity in posterior pelvic pain since pregnancy. Spine 27, 196–200.

Myer, G.D., Ford, K.R., Palumbo, J.P., Hewett, T.E., 2005. Neuromuscular training improves performance and lower-extremity biomechanics in female athletes. Journal of Strength and Conditioning Research 19 (1), 51–60.

Nadler, S.F., Malanga, G.A., DePrince, M.L., Stitik, T.P., Feinberg, J.H., 2000. The relationship between lower extremity injury, low back pain, and hip muscle strength in male and female collegiate athletes. Clinical Journal of Sports Medicine 10, 89–97.

Nadler, S.F., Malanga, G.A., Feinberg, J.H., Prybicien, M., Stitik, T.P., DeFrince, M., 2001. Relationship between hip muscle imbalance and occurrence of low back pain in collegiate atheletes: a prospective study. American Journal of Physical Medicine & Rehabilitation 80, 572–577.

O'Sullivan, P.B., 2000. Lumbar segmental 'instability': clinical presentation and specific stabilizing exercise management. Manual Therapy 5 (1), 2–12.

O'Sullivan, P.B., Beales, D.J., Beetham, J.A., et al., 2002. Altered motor control strategies in subjects with sacroiliac joint pain during the active straight-leg-raise test. Spine 27, E1–E8.

Paterno, M.V., Myer, G.D., Ford, K.R., Hewett, T.E., 2004. Neuromuscular training improves single-limb stability in young female athletes. Journal of Orthopaedic & Sports Physical Therapy 34 (6), 305–316.

Risberg, M.A., Mork, M., Krogstad Jenssen, H., Holm, I., 2001. Design and implementation of a neuromuscular training program following anterior cruciate ligament reconstruction. Journal of Orthopaedic & Sports Physical Therapy 31, 620–631.

Rutherford, O.M., 1988. Muscular coordination and strength training, implications for injury rehabilitation. Sports Medicine 5, 196.

Sigward, S.M., Powers, C.M., 2006. The influence of gender on knee kinematics, kinetics and muscle activation patterns during side-step cutting. Clinical Biomechanics 21 (1), 41–48.

Van Dillen, L.R., McDonnell, M.K., Fleming, D.A., Sahrmann, S.A., 2000. The effect of hip and knee position on hip extension range of motion measures in individuals with and without low back pain. Journal of Orthopaedic & Sports Physical Therapy 30 (6), 307–316.

Vogt, L., Banzer, W., 1997. Dynamic testing of the motoral stereotype in prone hip extension from the neutral position. Clinical Biomechanics 12, 122–127.
Vogt, L., Pfeifer, K., Banzer, W., 2003. Neuromuscular control of walking with chronic low-back pain. Manual Therapy 8, 21–28.
Zazulak, B.T., Ponce, P.L., Straub, S.J., Medvecky, M.J., Avedisian, L., Hewett, T.E., 2005. Gender comparison of hip muscle activity during single-leg landing. Journal of Orthopaedic & Sports Physical Therapy 35 (5), 292–299.