Physical Fitness and Healthy Low Back Function

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HIGHLIGHT

The development and maintenance of healthy low back function requires a balance of flexibility, strength, and endurance. Specifically, the critical components are:

a. low back lumbar flexibility;
b. hamstring flexibility;
c. hip flexor flexibility;
d. strength and endurance of the forward and lateral abdominals; and
e. strength and endurance of the back extensor muscles.

Include appropriate exercises for each group in your workouts, paying particular attention to your personal weaknesses.

Papers 6 and 7 in Section II gave a general overview of the benefits of physical activity and how those benefits related to major lifestyle diseases and the *Healthy People 2000* promotion and disease prevention priorities. This paper focuses on physical activity, physical fitness, healthy back function, and low back pain.

The following key points are discussed in detail in this article:

- At some time in their lives, 60–80% of all individuals experience low back pain. The condition is disabling to 1–5% of this population.
- To have a healthy, well-functioning back, flexible lumbar muscles, hamstrings, and hip flexors, and strong fatigue-resistant abdominal and back extensor muscles are necessary.
- The *Healthy People 2000* goals aim to decrease disability from chronic disabling disease and to increase the proportion of the population who regularly perform activities to enhance muscular strength, endurance, and flexibility. In terms of low back health, the latter goal may be one way of achieving the former goal.
- Exercises to maintain or increase muscular function in the low back region are presented in Table 13.1.
- The anatomical logic (presented in Table 13.2) linking low back health and physical activity is stronger than the research evidence at this time.

TABLE 13.1

Suggested exercises for various fitness levels.

NEUROMUSCULAR FITNESS COMPONENTS

a. Lumbar mobility*

b. Hamstring flexibility*

c. Hip flexor flexibility*

d. Abdominal strength/endurance**

e. Back extensor strength/endurance**

LOW

Knee to Chest

In supine lying position bring one or both knees to the chest, grasping the leg, under the thigh(s), raise and lower head slowly.

Modified Hurdler's Stretch

Sit with one leg straight, the other flexed. Move the flexed knee to the side and bend forward.

Hip Extension

Stand with pelvis in neutral position. Extend leg backward at hip.

Pelvic Tilt

In supine lying or standing position—press pelvis to floor or wall.

Hyperextension—1

Lying in prone position with hands at thighs. Keep neck and chin in neutral position and raise shoulders off floor.

MODERATE

"Mad Cat"

Kneeling on all fours alternate head up with sway back and head tucked with rounded back.

PNF Supine Position

Place jump rope around foot or ankle with leg raised as straight as possi- ble. Contract against rope, relax, and pull leg straighter. Repeat.

Lying Stretch

Lie on table with knees over the edge and back flat. Pulling one leg to the chest (hands on thigh) stretches the opposite hip.

Partial Curl (crunch)

Hook lying position, feet not held, tilt pelvis, curl up, sliding hands at side 3–4 $^{1}/_{2}$ inches.

Hyperextension—2

Lying in prone position with arms and hands extended forward. Keep neck and chin in neutral position and raise shoulders off floor.

HIGH

Crossed Leg Flexion

Sitting position with knees flexed and ankles crossed. Slowly bend forward until head approaches floor.

Standing Stretch

Stand with one leg placed on a support at about 90° hip flexion. Keeping back straight with shoulders back, flex forward.

Standing Stretch

Stand in forward backward stride position. Bend front knee and thrust back hip forward. Keep front knee over ankle.

Oblique Curl

Lying on side — twist trunk and curl up reaching for top leg with opposite arm.

Hyperextension—3

Lying in prone position on a table or bench with body supported and stabilized from top of pelvis down. Flex waist to 90° and extend to several inches above level.

TABLE 13.2

Theoretical relationship between physical fitness components and healthy/unhealthy low back/spinal function.

Physical Fitness Component

Cardiovascular Respiratory Endurance

Body Composition

Neuromuscular

a. Lumbar flexibility
b. Hamstring flexibility
c. Hip flexor flexibility
d. Abdominal strength/endurance
e. Back extensor strength/endurance

Normal Anatomical Function in Low Back—Healthy

Discs obtain nutrients and dispose of wastes by absorption from adjacent blood supply.

High musculature allows for proper functioning as outlined below and provides mechanical loading on the vertebrae for maintenance of bone mass.

Allows the lumbar curve to be almost reversed in forward flexion.

Allows anterior rotation (tilt) of the pelvis in forward flexion and posterior rotation in sitting position.

Allows achievement of neutral pelvic position.

Maintains pelvic position; reinforces back extensor fascia and pulls it laterally on forward flexion providing support.

Provides stability for spine; maintains erect posture; controls forward flexion.

Dysfunction

Poor circulation, low CVR endurance; atherosclerosis

High % body fat content

Inflexible

Inflexible

Inflexible

Weak, easily fatigued

Weak, easily fatigued

Results of Dysfunction—Unhealthy

May speed up disc degeneration.

Increases the weight the spine must support; may lead to increased pressure on discs or other vertebral structures.

Disrupts forward and lateral movement; places excessive stretch on hamstrings, leading to low back and hamstring pain.

Restricts anterior pelvic rotation and exaggerates posterior tilt; both cause increased disc compression; excessive stretching causes strain and pain.

Exaggerates anterior pelvic tilt if not counteracted by strong abdominal muscles, thereby increasing disc compression.

Allows abnormal pelvic tilt; increases strain on back extensor muscles.

Increases loading on spine; causes increased disc compression.

Studies (see body of text) support the fact that individuals who have suffered low back pain (LBP) have weaker, more fatigable, and less flexible muscles in the trunk region even after the acute pain episode has subsided than do those who are pain free. Continued weakness, low endurance, and restricted range of movement appear to be contributing factors to recurrent LBP. The ability to predict first-time LBP from muscular strength, endurance, or flexibility values has not been established. Likewise, a direct relationship between LBP and cardiovascular or body composition fitness has not been established. On the other hand, with one exception, which is noted in the following text, the studies reviewed have not shown that high levels of any of these fitness components are in any way linked as causal factors to LBP. Therefore, it appears prudent at this point to continue recommending a specific program of truncal muscular fitness as a part of a comprehensive physical fitness activity program. This recommendation is in accordance with the *Healthy People 2000* goal, which states the aim of increasing to at least 40% the proportion of the population six years old and above who regularly perform physical activities that enhance and maintain muscular strength, muscular endurance, and flexibility (Public Health Service, 1990). A comprehensive program would, of course, utilize the entire body and, along with the trunk region, stress upper arm and shoulder girdle areas. While baseline data suggest that the goal is close to being met for high school students, for the total population the 1991 estimate is that only 16% are involved in such programs.

For the trunk and low back region, it is imperative that the neuromuscular program go beyond traditional sit-ups for abdominal strength (actually, partial curls should be substituted for sit-ups) and modified hurdler's stretches for hamstring flexibility. The exercise program should be designed to include all five major anatomical areas and abilities listed in Table 13.1 without overemphasizing lumbar flexibility. Ignoring any element in the whole may lead to imbalances. Table 13.1 presents suggested flexibility and muscular strength/endurance exercises for the five identified areas with a progression from relatively easy to reasonably hard. Individual selections can be made from this chart for each area. Even if these components have not been shown irrevocably to be protective against the development of LBP, truncal muscular strength, endurance, and flexibility are important aspects of a healthy, fully functioning, fit body.

It should be noted that the activities listed in Table 13.1 are limited to those that require no specialized equipment, not even free weights. They may, thus, be less than the optimal exercise. For example, evidence is accumulating that back extensor exercises done on a specialized machine (the MedX™) that stabilizes the pelvis provides the best results. Without pelvic stabilization, back extension strength may not be developed (Foster & Fulton, 1991; Risch et al., 1993).

TABLE 13.1

SUGGESTED EXERCISES FOR VARIOUS FITNESS LEVELS.

NEUROMUSCULAR FITNESS COMPONENTS

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b. Hamstring flexibility*
c. Hip flexor flexibility*
d. Abdominal strength/endurance**
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Hyperextension—3

Lying in prone position on a table or bench with body supported and stabilized from top of pelvis down. Flex waist to 90° and extend to several inches above level.

THE PROBLEM

The incidence of low back pain has been and continues to be consistently high. At some time in their lives, 60–80% of all individuals experience back pain. Both sexes are affected equally. Most cases occur between the ages of 25 and 60 years, but no age is completely immune. Fortunately, most LBP is acute and, with or without treatment of any kind, resolves itself within three days to six weeks. After six weeks to a year, the condition is considered to be chronic. For the 1–5% so afflicted, the condition is disabling. This statistic speaks directly to the *Healthy People 2000* priority of reducing disability from chronic disease, for while LBP is not the most prevalent disabling disease in the U.S., it is one of the many (Public Health Service, 1990). The psychological, social, and physical costs to individuals cannot begin to be calculated. The medical, insurance, and business/industry costs have been estimated into the billions of dollars per year (Cailliet, 1988; Plowman, 1992; Kumar, 1994).

Most cases of acute LBP arise spontaneously from no known cause. Without knowing the exact cause or causes of LBP, it is difficult to determine risk factors that might predispose an individual to LBP. Among the possible risk factors most commonly linked with LBP is a lack of physical fitness. Indeed, LBP has often been labeled as a hypokinetic disease, that is, as a disease caused by and/or associated with a lack of exercise (Kraus and Raab, 1961).

THE THEORETICAL LINK BETWEEN PHYSICAL ACTIVITY, PHYSICAL FITNESS, AND LOW BACK PAIN

The theoretical link between physical activity, physical fitness, and LBP is largely based on functional anatomy Anatomically, back pain is primarily located in the lumbosacral region of the back, which normally forms a lordotic curve. Twenty-four vertebrae comprise the entire spine. Effective functioning of the back requires coordination of all of the vertebra, the pelvis, the hip and thigh joints, and the muscles, fascia, and ligaments which originate and insert on these bones. Such coordination is task-specific, but to be normal it should be completed with minimal and equalized stresses within the spine (Cailliet, 1988; Gracovetsky, 1990).

Table 13.2 presents the theoretical relationships between all of the components of health-related physical fitness and healthy and unhealthy functioning of the low back. It can be seen that there is a strong anatomical rationale for all components of fitness. The actual research-based support is not as strong as the anatomical relationships.

THE RESEARCH LINK BETWEEN PHYSICAL ACTIVITY, PHYSICAL FITNESS, AND LOW BACK PAIN

Types of research studies. Studies that have attempted to determine the relationship between physical activity and/or fitness and low back function or pain/injury are of two primary types. The first are retrospective studies. In a retrospective study, the relationship between the activity or fitness component and LBP is examined, or an attempt is made to distinguish between those who do and do not have low back pain based on the activity or fitness score. Retrospective studies must be interpreted cautiously since there are at least three possible confounding problems. First, activity or fitness measures in individuals already suffering from LBP may represent less than maximal effort due to real or feared pain. Second, physical activity is generally spontaneously decreased in individuals suffering from LBP, with the result that scores may reflect detraining as much as LBP per se. Third, these studies statistically establish just relationships (some of which may be statistically significant but not practically meaningful) and not cause and effect.

The second type of study is prospective. Prospective studies are longitudinal studies that test either normal individuals with no history of LBP, individuals with a history of LBP, or both, and then wait a specified time to see who develops LBP. The initial activity or fitness variables are then statistically analyzed to determine which, if any, had the most predictive value for the development of LBP. Prospective studies are obviously more valuable but they are also harder to conduct.

Throughout this section it has been emphasized that either physical activity or physical fitness can be used to determine the linkage with low back health or pain. In point of fact, very few studies have even attempted to relate physical activity per se in nonathletic populations with LBP. Those that have examined activity are weak in design and contradictory in outcome, precluding any meaningful comments or conclusions. The biggest difficulty is the inconsistent classification of physical activity and a primary reliance on frequency of participation to the exclusion of duration and intensity (Plowman, 1992). Even the most direct study by Porter, Adams, and Hutton (1989), which found a significant positive relation between spinal motion segment compressive strength and physical activity in young men killed in motorcycle accidents, relied only on a sports history obtained from the next of kin.

A more recent 10-year prospective study by Leino (1993) did attempt to classify activity levels into an exercise activity score (EAS = duration 3 estimated energy expenditure for light, moderate, or strenuous intensity), a strenuous activity score (SAS = 500 kcal day^{21} or more), and a total activity score (travel to and from work, housework, and exercise). Back morbidity was assessed by both subject symptoms and clinical examination. At baseline, none of the physical activity scores was statistically related to low back problems. Males exhibited greater stability in EAS and SAS than females. Prospectively, for the males but not the females, the lower EAS and/or SAS scores at baseline and five years, the higher the low back problems after 10 years. When adjusted for other lifestyle factors, the SAS rating was not as consistently predictive as that of the EAS. Part of the difficulty in discerning the relationship between physical activity and low back pain is that it may be U-shaped. That is, both no or too little activity and extremely strenuous activity (either absolute or relative to an individual’s capabilities) may predispose an individual to low back problems. Thus, no exercise prescription guidelines specific for low back health can be documented from the literature. This is a fertile area for research.

The rest of this report will concentrate on the linkage between physical fitness and low back health or pain. Some specific studies will be mentioned for illustrative purposes, but the primary emphasis will be on general consensus. For a more in-depth presentation of the research literature, the reader is referred to Plowman (1992). Complete references are also provided there.

CARDIOVASCULAR FITNESS AND LBP

As stated in Table 13.2, a properly functioning cardiovascular system is necessary for disc nourishment and to slow disc degeneration. The exact relationship with total body cardiovascular fitness has received little attention. Only two retrospective studies have measured cardiovascular fitness, and neither established a definitive linkage with low back function (Plowman, 1992).

Likewise, only two prospective studies have designs specific enough to draw conclusions from, but unfortunately the conclusions that must be drawn are in opposition to each other. The first study was completed on fire fighters by Cady, Thomas, and Karwasky (1985). Cardiovascular condition was assessed by physical working capacity (PWC). The 20 fire fighters with the lowest PWC incurred much higher low back injury costs than the 20 with the highest PWC, showing a beneficial effect. The second study is the study with the stronger design. It was conducted by Battié et al. (1989). Maximal oxygen consumption (VO_2max) was predicted from a submaximal treadmill test on over 2,400 Boeing airplane employees. VO_2max was not found to be predictive of the 228 back problems which occurred in these employees over the subsequent four years.

Haliovaara et al. (1995) have presented epidemiological evidence against the theory that atherosclerosis (the narrowing of blood vessels as a result of the build-up of plaque) contributes to the development of LBP by determining death rates from cardiovascular disease in individuals with and without LBP. Comprehensive health examinations were performed on 7,217 individuals representative of the Finnish population. Seventy-six percent had a history of LBP complaints; 17% were diagnosed with chronic LBP. Twelve to 14 years later, 1,487 individuals had died from cardiovascular disease. Neither a history of LBP complaints nor diagnosed chronic LBP predicted cardiovascular mortality.

There is no evidence that a highly fit cardiovascular system is detrimental in any way, but the evidence of benefit is minimal. This is another area which requires further research.

BODYCOMPOSITION AND LBP

The skeletal system in general and the spine in particular are the primary supporting structures of the body. As pointed out in Table 13.2, if the weight the spine supports is largely muscular and the muscles are both strong and flexible, healthy functioning should result. However, if a large portion of the body mass is fat, this adds excess weight and pressure on the discs without any positive assistance. The few studies which have utilized body mass index (WT/HT^2) (BMI) and/or skinfolds as an indication of body composition have shown split results. However, an analysis of the NHANES-II national probability sample data set did show a substantial increase in LBP prevalence (1.7 times higher) in the most obese 20% compared with the least obese 20% of the 10,404 adult subjects when obesity was defined by both BMI and skinfold measures. No studies have been done on LBP in which body composition has been directly assessed by a laboratory criterion measure such as underwater weighing (Plowman, 1992).

NEUROMUSCULAR FITNESS AND LBP

The most important components of fitness in relation to healthy functioning of the low back are muscular strength, muscular endurance, and flexibility. It is necessary that each separate muscle group possess both strength/endurance and flexibility, and that anatomically opposing muscle groups are balanced in strength/endurance and flexibility. The goal in relation to the low back region is that the vertebra will be kept in proper alignment without excessive disc pressure throughout the full range of possible motions. In addition, the pelvis must freely rotate both posteriorly and anteriorly without strain on the muscles or fascia. Table 13.2 presents the specific actions of the back, hip, abdominal, and hamstring muscles and what can theoretically happen if these muscles are allowed to become weak, easily fatigued, and/or inflexible.

The research evidence shows that regardless of the testing mode (that is, whether the test is one of static or dynamic function), individuals with low back pain exhibit lower strength values of both the abdominals and back extensor groups than do individuals without LBP. Only two studies looked at trunk extensor endurance specifically, but both of these found that individuals with LBP severe enough to limit function had scores lower than those without such limitations (Plowman, 1992).

Perhaps the most interesting studies in this area are those utilizing electromyographic (EMG) analysis of back extensor fatigue. In each of the three studies (DeVries, 1968, Roy, DeLuca, & Casavant, 1989; Roy et al., 1990), 80–100% of those with LBP showed increased electrical activity during sustained static muscle contraction. While these were not intended to be prospective studies, in one case an individual who showed high EMG activity but no history of LBP developed LBP the following year. Retrospective studies of low back pain and hamstring flexibility have shown the same trend. That is, there is a significant relationship between tightness in those muscle groups and LBP (Plowman, 1992).

Prospective studies of neuromuscular fitness are neither as numerous nor as definitive as the retrospective ones. Only one strength/endurance study found any variable predictive of first-time low back pain, and this showed the predictive variable to be limited (low) back extensor endurance (Biering-Sorensen, 1984a). Unfortunately, this was the only study using this variable, but since it is consistent with the results of the retrospective studies it would seem that back extensor endurance needs to be given more attention. Recurrent back pain has been successfully predicted in about half of the studies of trunk and back extensor strength/endurance with, as expected, low scores preceding the reoccurrence of back pain (Plowman, 1992).

One prospective study found lumbar flexibility to be predictive of first-time LBP (Biering-Sorensen, 1984b). In it, increased (not decreased as might be expected) lumbar mobility was found to be predictive of first-time back pain in males but not females. It is anatomically possible that extreme lumbosacral flexion stresses the discs at that site (Sharpe, Liehmon, & Snodgrass, 1988). Recurrent back pain has been found to be predictable from both low lumbar extension range of motion and low hamstring flexibility.

No specific level of strength, endurance and/or flexibility has emerged as critical in any of these studies. Hopefully, further research to clarify these issues will be forthcoming.

Part of the difficulty in experimentally being able to provide evidence concerning the relationship of lumbar extension and flexion strength, endurance, and flexibility and low back pain may be in the previously available equipment. Specifically, testing of the lumbar extensor muscles without stabilization of the pelvis may have led to inaccurate results and conclusions. If the pelvis moves during testing, the force measured also includes some unknown contribution from the hip extensors and is not truly a measure of back extension strength (Jones, 1993).

CHILDREN / ADOLESCENTS AND LBP

Historically, LBP in adolescents and especially children was considered indicative of a serious pathological condition, either anatomical or physiological (King, 1986). Statements such as "backache is so rare in the prepubertal and early pubertal patient that such patients should undergo a complete work-up for a serious cause...." (Dymet, 1991, p. 170) were commonplace. Today, however, evidence is mounting that LBP is no longer rare in this age group. Over half a dozen large sample studies of Scandinavian and European children in the past decade (Balague, Dutoit, & Waldburger, 1988; Balague et al., 1993; Burton et al., 1996; Mierau, Cassidy, & Yong-Hing, 1989; Salminen, Pentti, & Terho, 1992; Taimela et al., 1997; Troussier et al., 1994) have shown that the incidence of LBP is relatively low prior to puberty (1–28%) but falls very close (50–80%) to the adult range by the early- to mid-teen years. Some studies report that young females have more LBP than young males, but the role of back discomfort associated with the menstrual cycle does not appear to have been clarified in these studies.

The relationship between physical activity and LBP in children and adolescents suffers from the same ambiguities as for adults. In most studies, youngsters both with and without LBP have been evenly distributed into low, moderate, and high activity groups (Balague et al., 1993; Kujala et al., 1992; Salminen, 1984; Taimela et al., 1997; Troussier et al., 1994). In one study (Salminen et al., 1995) low participation in activity was associated with increased frequency of LBP. However, in still others, high participation, especially in heavy sports training, has been associated with an increased incidence of LBP (Balague, Dutoit, & Waldburger, 1988; Burton et al., 1996; Kujala et al., 1992; Taimela et al., 1997).

Cardiovascular fitness has not been investigated in relation to LBP in this age range, but several attempts have been made to relate anthropometric variables to LBP. Neither height, weight, nor body mass index (BMI) has been shown to be predictive of future LBP (Salminen et al., 1993; Salminen et al., 1995). However, a tall sitting height and a high degree of asymmetry as measured by the forward bending test may play a modest role in LBP (Fairbank et al., 1984; Nissinen et al., 1994).

Isokinetic trunk flexion and extension strength were found to be no different between 10- and 16-year-olds with and without LBP (Balague et al., 1993); however, both abdominal and back extensor muscular endurance did differ significantly between youngsters with and without LBP (Salminen et al., 1993). These muscular endurance measures, however, were not predictive of LBP in a three-year follow-up study (Salminen et al., 1995).

Flexibility measures have been shown to be positively, negatively, and nonsignificantly related to LBP (Burton et al., 1989; Burton et al., 1996). A positive relationship means that a high degree of mobility is associated with LBP. High lumbar mobility was apparent in children and adolescents with LBP but, unlike the Biering-Sorensen (1984a) results in adults, was not found to be predictive of LBP in youngsters (Salminen et al., 1993; Salminen et al., 1995). Decreased hamstring flexibility (Mierau, Cassidy, & Yong-Hing, 1989; Salminen et al., 1993; Salminen et al., 1995), decreased femoral and tibial rotation (Fairbank et al., 1984), and decreased lumbar extension and flexion (Salminen et al., 1993; Salminen et al., 1995) have all been associated with increased LBP in children and adolescents, but no evidence exists that any of these can predict future LBP.

Thus, the pattern of the relationship between physical activity and/or physical fitness variables is no clearer in children and adolescents than in adults. It does seem that LBP is more of a problem in children and adolescents than previously thought. However, for individuals of all ages the key may be in the degree of the predisposing factors, not just whether an individual is active, strong, or flexible. Continued investigation into factors predictive of LBP in children and adolescents is important to try to avoid LBP at this age, but it is also important because a better understanding of LBP in children and adolescents may yield clues to the origins of adult LBP and to a means of prevention. In the meantime, moderate levels of activity are to be encouraged for all since, at the very least, this level of activity appears to do no harm to the back.

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