

Back Fitness and Back Health Assessment Considerations for the Canadian Physical Activity, Fitness and Lifestyle Appraisal

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Abstract/Résumé

The Canadian Physical Activity, Fitness, and Lifestyle Appraisal (CPAFLA) is used as a measure for the health-related fitness of the general population. The CPAFLA includes an evaluation of back health, which is comprised of abdominal muscular endurance (partial curl-ups) and trunk flexion (sit and reach). This paper reviews the occupational, lifestyle, and physical risks associated with back pain and examines the measurement techniques used to assess health-related fitness components of back health in fitness assessments, such as the CPAFLA. Recommendations for future revisions of the CPAFLA's back health assessment and future research needs are presented.

Le guide Canadien pour l'Évaluation de la Condition Physique et Habitudes de Vie (ÉCPHV) consiste en une approche simple et normalisée permettant d'évaluer les principales

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composantes de la condition physique et des habitudes de vie en relation avec la santé de la population canadienne. Le guide de l'ÉCPHV comprend une évaluation de la santé du dos qui comprend l'endurance des muscles abdominaux (redressement assis partiel) et la flexibilité du dos (flexion avant du tronc). Cet article examine les risques associés au développement des lombalgies par rapport à l'occupation, les habitudes de vie et la condition physique. L'article revise aussi les mesures d'évaluation de la santé du dos ainsi que leur utilisation dans le guide canadien de l'ÉCPHV. Enfin des recommandations en ce qui concerne une révision prochaine du Guide par rapport à l'évaluation de la santé du dos et les besoins en matière de recherche sont aussi proposées.

Introduction

Spinal problems, specifically lower back pain (LBP), continue to be a significant public health concern. The epidemiological figures commonly reported indicate that LBP has between a 70% and 85% lifetime prevalence and an annual prevalence of 15–45%, making LBP one of the leading causes for seeking medical attention (Andersson, 1991; Erdil et al., 1997; Granhed et al., 1987). Fortunately, over half of LBP episodes resolve themselves within 1 week, 90% in 6 weeks, and up to 95% in 12 weeks (Bishop et al., 1997; Erdil et al., 1997; Nachemson and Bigos, 1984). In the remaining cases, pain may persist well over 6 months progressing to a chronic stage (Nachemson and Bigos, 1984). Despite the apparent self-limiting nature to LBP episodes, the 1-year recurrence rate has been suggested to be as high as 44%, making prior LBP a strong predictor for future back problems.

The concern is further elevated by the increasing burden placed on healthcare and workplace compensation systems due to the high prevalence of occupationally related LBP. In the province of Ontario, for example, soft tissue injuries account for 60–65% of all workforce claims, 40% of which are related to back pain and injury (Frank et al., 1996). In 1999, the Canadian Centre for Occupational Health and Safety (CCOHS) reported that each year 8,000 Canadian workers are permanently disabled by back injuries while many others are not able to return to work (Canadian Centre for Occupational Health and Safety, 1997). Such back injuries accounted for about one-third of all lost work and 40% of all compensation costs in Canada. Abenheim and Suissa (1987) reported that 1.37% of the work force of Quebec was absent from work as a direct result of occupational LBP, resulting in a total cost of 173 million dollars. Therefore, LBP poses a large burden on society in terms of lost work time translating into significant costs to both the employer and employee.

The difficulty, from a clinical standpoint, is that the origin of LBP is multifactorial and there are substantial limitations in the current diagnostic technology (Computer Tomography, Magnetic Resonance Imaging and X-rays; Gracovestsky et al., 1990) to reach a precise diagnosis in 80–90% of LBP patients (Frymoyer et al., 1980; Spratt et al., 1990). There has always been a strong belief that impaired muscular function contributes to LBP development, as such clinical evaluations include functional assessments to quantify the severity of impairment (Masset et al., 1993; Mayer et al., 1984; Rainville et al., 1996). The incorporation of tests to evaluate trunk and hamstring flexibility (toe-touch test or sit-and-reach test) and abdominal strength/endurance (sit-up or curl-up) are also commonplace in most

leading fitness appraisal programs including the AAPHERD Health Related Physical Fitness Test (AAHPERD, 1984) and FITNESSGRAM™ (CIAR, 1992) and Canada's Physical Activity, Fitness and Lifestyle Appraisal (CPAFLA; CSEP, 1996). In recent years, however, functional assessments such as the curl-ups and sit-and-reach tests have been criticized for their lack of criterion-related validity with respect to LBP assessment (Jackson and Baker, 1986; Jackson and Langford, 1989; Jackson et al., 1998; Jackson et al., 1996; Karageanos, 1998; Plowman, 1992).

In light of these criticisms and concern for the prevalence and cost of LBP in society, an examination is warranted of the current status of back fitness assessment and its implications for fitness appraisal protocols such as the CPAFLA. This paper reviews the most commonly cited health-related risk factors associated with back pain and the assessment techniques used to evaluate physical components related to back fitness. This review provides the basis for recommendations to enhance the evaluation of back fitness.

CPAFLA and Back Fitness

The current (CSEP, 1996) includes five appraisal measures that focus on muscular fitness: grip strength and the vertical jump as indicators of muscular strength and power, the push-up and partial curl-up to assess muscular endurance, and the forward trunk flexion to determine range of motion in the hip joint. Back health is evaluated as a composite of the partial curl-ups and the sit and reach (S&R) test results.

The partial curl-up is administered to assess abdominal muscular endurance (CSEP, 1996). Clients begin lying on a mat in a supine position with knees bent at an angle of 90°, arms straight at their sides parallel to the trunk, palms down on the mat with the middle fingers of each hand resting at the starting line. While keeping the feet and palms of the hands on the mat, the upper spine is slowly curled up, far enough that the middle finger tips of each hand reach the line 10 cm forward from the start line. To complete the curl-up, the shoulder blades and head must be lowered to contact the mat and the fingertips of both hands returned to the start line. The movement is performed in a slow manner, cadence controlled by a metronome set at 50 beats per minute. The curl-up assessment is continuous, with the fitness appraiser recording the number of consecutive curl-ups performed, without pausing, to a maximum of 25 in a 1-min time period.

Trunk flexion is evaluated with the sit and reach test (CSEP, 1996). To begin, the client sits with legs fully extended and the soles of their feet against the flexometer. Keeping the legs and arms fully extended, the client bends forward, in a smooth and controlled manner, as far as possible, pushing the sliding marker with their fingertips. The fully flexed position is held for a 2-s period. The readings from two consecutive tests are recorded, and the best one represents the S&R score.

The results from these tests are compared against normative data tables representing health benefit zones by age groups and gender. The zones range from *Needs Improvement* through to *Excellent* with regard to overall back fitness. Ratings of *Needs Improvement* or *Fair* indicate that corrective measures are in order, and the client is provided with guidelines for improvement together with general information on maintaining a healthy back.

Associated Risk Factors to Back Pain

It is well established that the best single predictor of recurring back pain is a previous episode of back pain (Bigos et al., 1986a; Frank et al., 1996). However, this does not discount the complex and multifaceted nature of its development. It is not enough to simply understand the physical components (attributes and muscular function), which contribute to trunk motion, but an incorporation of the psychosocial and lifestyle behaviours of the individual seem to be of equal importance. Supporting evidence regarding individual factors and their relationship to increased LBP injury risk is far from complete, and the research literature is frequently contradictory. The relationship between potential risk factors and back pain is often difficult to determine because (a) back pain and back injury are not easily defined; (b) absenteeism in the workplace data are influenced not only by pain, but also by physical and psychological work factors, social support factors, and the insurance system policies; (c) exposure to specific risk factors is often difficult to determine; and (d) there is a poor or contradictory relationship between many physical tests and back disability (Pope et al., 1991).

Most research studies are restricted to using insurance reports, company medical reports, or self-reports (questionnaires) to determine the LBP outcome measure. These are usually limited in scope in that they indicate the occurrence of a LBP episode but are void of any specific etiology or diagnosis. Disability questionnaires have also been used in the clinical and research settings to evaluate LBP as they typically include questions concerned with symptom severity and functional limitations. The Functional Rating Scale (Evans and Kagan, 1986), the Roland-Morris Questionnaire (Roland and Morris, 1983; Stratford and Binkley, 1997; Stratford et al., 1998), the Oswestry Questionnaire (Esola et al., 1996; Hazard et al., 1991), and the Lower Extremity Functional Scale (Fairbank et al., 1980) are a few examples of self-reported instruments used to assess disability related to LBP. The Oswestry scale, for example, was designed to quantify the level of functional disability imposed by a person's back or leg pain. The functional activities included are personal care, lifting, walking, sitting, standing, sleeping, sex life (optional, if applicable), social life, and traveling. The Oswestry Disability Index is determined from the score on each of the 10 items, where a higher score represents a greater degree of functional disability in daily living activities. A high test-retest reliability (ICC = .99) and good internal consistency have been reported (Fairbank et al., 1980) for the Oswestry Scale. Although, questionnaires provide a convenient way of obtaining the required outcome measure, there is some concern over potential discrepancies between patients' perception of their functional status and performance on functional tests (Fordyce, 1984; Simmonds et al., 1998).

The multifaceted nature of LBP has demanded a multidisciplinary approach to its evaluation and treatment. Table 1 outlines many of the more commonly cited risk factors broadly categorized under individual and occupationally related factors. It is understood that these categories are not mutually exclusive, however they are presented in this manner for the sake of discussion purposes. The headings identified in Table 1 will be used in reviewing the major risk factors in the following sections. The review focusing on muscular fitness factors will be coupled with a discussion of assessment protocols for consideration within the CPAFLA.

Table 1 Common Risk Factors Cited as Being Associated With Lower Back Pain

Individual Risk Factors	Occupational Risk Factors
<i>Demographic Factors</i>	<i>Postural Factors</i>
age	sitting and standing
gender	akward/bent posture
ethnicity	static work posture
<i>Psychological Factors</i>	<i>Psychological Factors</i>
stress/anxiety	stress/anxiety
depression	work dissatisfaction
personality traits	social support
coping skills	monotonous work
<i>Socio-Economic Factors</i>	<i>Mechanical Factors</i>
income	lifting
domestic difficulties	twisiting
educational level	bending
social support	pushing/pulling/carrying
<i>Health & Lifestyle</i>	heavy physical work
body weight & height	repetitive work
physical activity & fitness	vibration
pregnancy	slips, trips and falls
medical history	
nutrition	
use of medications	
alcohol abuse	
smoking	
<i>Muscular Fitness Factors</i>	
trunk flexibility	
back endurance	
back strength	
leg strength	
abdominal strength	
abdominal endurance	
hamstring flexibility	

Occupationally Related Risk Factors

There is an ever-increasing concern for the high prevalence of LBP in occupational populations. Despite increases in mechanization, people are still required to engage in physically demanding activities in the workplace. The National Institute for Occupational Safety and Health has indicated that approximately two-thirds of overexertion injury claims involve lifting, and about 20% involved pushing and

pulling activities (NIOSH, 1991). A significant amount of effort has been placed on the determination of safe lifting, pushing, and pulling capacities during 8- and 12-hr workdays (Chaffin and Page, 1994; Ciriello et al., 1990; Mital, 1983) as well as proper lifting technique for loads of various shapes and sizes (Forssell, 1980; Hagen et al., 1994; Kumar, 1984; Mattmiller, 1980; Parnianpour et al., 1987). Instructions for safe lifting include using the legs, keeping the load close to the body, avoiding heavy loads, reducing excessive trunk bending and twisting, and decreasing repetitious lifting (NIOSH, 1991). Prolonged sitting, standing, and static postures have also been linked to LBP development with the risk increasing significantly with exposure to vibration in any of these postures.

Strong correlations have been found between psychosocial factors and LBP. In the classic Boeing Study, retrospective findings revealed a relationship between poor employee performance appraisals within 6 month of a LBP incidence among the 31,200 employees evaluated (Bigos et al., 1986a, 1986b). In their follow-up prospective study, the researchers found that non-physical factors were major predictors of LBP (Battié and Bigos, 1991; Bigos et al., 1991). Once again, job satisfaction was determined to be the greatest influence on acute back injuries. Other prospective studies have linked dissatisfaction with income, work, and social class (Papageorgiou et al., 1997) and the absence of a confidante (Stevenson et al., in press) to the development of LBP in industrial populations. Other psychosocial factors include mental stress, social support, domestic status, stress and pain coping mechanisms, personality traits, addictive behaviours, and education level. These psychosocial factors are strong predictors of how individuals will respond to LBP (Cats-Baril and Frymoyer, 1991).

Although the exposure to certain occupational risk factors is somewhat job specific, many of the psychosocial and postural factors are common across white and blue collar jobs. The average person spends one-third of his/her life working, making workplace risk factors an important component of back health assessment.

Individual Related Risk Factors

AGE AND GENDER

The first incidence of back pain normally occurs in young adulthood and reaches its maximum frequency during the most productive ages of 35 to 55 years (Ferguson and Marras, 1997). The incidence continues to increase in men until around age 40 (Biering-Sørensen, 1982) and in women past the age of 55 (Biering-Sørensen, 1982; Hirsch et al., 1969). The shift to less physically demanding jobs is usually associated with seniority, and this may account for the plateau of LBP incidence around the age of forty. The difference between men and women may be attributed to an increase in osteoporosis as women advance in age (Andersson and Pope, 1991). In general, the incidence of LBP is the same for women and men when occupational factors are not considered (Andersson, 1981; Helliövaara, 1989). Higher incidences of LBP are reported among females in occupations requiring high physical demands (Chaffin, 1974), accounted for by the lower strength of females, on average.

HEALTH AND LIFESTYLE BEHAVIOURS AND BACK HEALTH

Adherence to good lifestyle behaviours is an integral component to an individual's health and well-being. The association between physical activity level and overall physical fitness, including maintenance of a healthy body mass, has been well known for decades. The negative health effects of smoking have also been publicized to the general population. Although the relationships of physical activity, physical fitness, body mass, and smoking with overall health are well established, these relationships are much more equivocal when it comes to back health.

Smoking. A recent longitudinal study, in which risk factors associated with the development of LBP in an industrial population were investigated over a 2-year period, identified tobacco smoking as a negative health and lifestyle factor (Stevenson et al., in press). Previous longitudinal (Battié et al., 1989a; Biering-Sørensen, 1984a, 1984b; Cady et al., 1979; Chaffin and Park, 1973; Frymoyer et al., 1980, 1985; Leino, 1993; Svensson and Andersson, 1983; Troup et al., 1981), cross-sectional and retrospective studies (Frymoyer et al., 1983, 1980, 1985; Lindh, 1996) have also reported similar findings. In a cross-sectional study of 10,404 adults, back pain prevalence was found to rise with increasing levels of smoking to a prevalence among those smoking three or more packs a day to be almost twice that of nonsmokers (Deyo and Bass, 1989). The authors (Deyo and Bass, 1989) suggest that smoking may be "a marker for other behaviors that increase [LBP] risk," rather than a causal effect of LBP. Three hypotheses for the causal effect of smoking have been put forth: (a) that smoking was related to anxiety and depression which may intensify the LBP (Deyo and Bass, 1989; Frymoyer et al., 1980), (b) that smoking might produce hormonal changes that increase LBP by reducing discal metabolism (Frymoyer et al., 1980; Holm and Nachemson, 1984), and (c) that chronic coughing may increase intradiscal pressures promoting disc herniation (Kelsey, 1975; Kelsey et al., 1984). Despite these arguments for smoking as a "marker for other behaviours," the extent of the related smoking literature would suggest that people who smoke are more apt to report LBP.

The CPAFLA's FANTASTIC lifestyle questionnaire records the smoking habits, along with a number of other lifestyle behaviours, to highlight potential lifestyle changes that may be recommended to the client in order to achieve health benefits. The smoking score, therefore, could be used as an additional marker for the assessment of back risk within the context of the CPAFLA.

Body mass and waist girth. The negative relationship between excess body fat and LBP has been assumed on intuitive grounds; that is, the more abdominal fat, the greater the stress on the back. A recent cross-sectional study obtained body mass index (BMI) and waist girths (WG) to determine their relationship to back health in 520 Canadian men and women (Payne et al., 2000). It was reported that only girth (WG) was negatively related to LBP in both males and females, consistent with previous cross-sectional studies (Han et al., 1997; Lean, 1998). The authors recommended that WG, currently measured in the CPAFLA protocol, be used to enhance back health assessment. Some studies have found the relationship with body composition to be more pronounced in women than men. Lean (1998) reported women were 1.5 times more likely to have LBP symptoms when WG measured above 88.0 cm after adjustment for other lifestyle confounding factors.

BMI has been widely used as a predictor of obesity despite concerns over its effectiveness as a risk indicator since it does not account for fat distribution. In an 11-year follow-up study, BMI was determined to be an independent risk factor for herniated lumbar disc development in males only (Heliövaara, 1987). Other studies were unable to find a significant difference in groups of industrial workers (painters, construction workers; Riihimaki et al., 1989a) or police officers (Brown et al., 1998) with and without LBP based on height, weight, or BMI. The effect of obesity on trunk muscular fatigue has received attention from some researchers. Kankaanpää et al. (1998) found that the electromyographic median frequency decline, an indication of fatigue, during the Biering-Sørensen trunk endurance test was dependant on age and BMI, and this relationship was more pronounced in women than men. However, Moffroid et al. (1994) did not find obesity level to have an effect on trunk endurance times.

These studies would suggest that, at this time, there is some indication that obesity, especially WG, may lead to back problems and reduced spinal flexibility for men and women.

Physical activity and physical fitness. The reported correlation between physical activity and LBP development is inconsistent in the literature. Recently, Payne et al. (2000) used the Healthy Physical Activity Participation Questionnaire (Shephard and Bouchard, 1994), currently administered in the CPAFLA, to compare the physical activity levels in a group of 520 Canadian adults. The authors found that self-reported physical activity level was able to discriminate between the 428 no back pain sufferers and the 112 who reported a history of back pain. Saraste and Hultman (1987) conducted a cross-sectional study to investigate life conditions, including leisure time activities, of 2872 Swedish citizens with and without LBP. They found no differences in any leisure activity variables including physical activity variables. In prospective studies of metal workers (Leino, 1993) and manual material handlers (Stevenson et al., in press), a modest inverse linear relationship associating leisure time physical activity (self-reports) and development of LBP symptoms was found. However, previous studies on industrial populations were not able to document a similar relationship between leisure time physical activity and the occurrence of LBP (Riihimaki et al., 1989b). Separate investigations with nurses found positive associations between aerobic exercise and LBP (Mandel and Lohman, 1987) and frequent physical activity and sciatic pain (Videman et al., 1984).

Regular sports participation by adults has resulted in contradictory findings. Gyntelberg (1974), for example, reported an association between regular sport participation and lower LBP incidence in a Danish male population (Gyntelberg, 1974); however, similar participation was conversely found to increase the risk of LBP in a separate adult population (Burton et al., 1989a). Increased risk in disc disease has been suggested with specific involvement in sports such as golf, bowling, and baseball (Biering-Sørensen and Thomsen, 1986; Kelsey, 1975).

A classic study conducted on 1,652 Los Angeles fire fighters is often quoted for demonstrating a positive relationship of lower incidence of LBP injury and high cardiovascular fitness (Cady et al., 1979). Fire fighters' fitness level was classified as "low," "moderate," or "high" based on a battery of physical fitness tests including physical work capacity (bicycle ergometer test), diastolic blood pressure, muscular strength, and flexibility. The "low fitness" group (lowest 16

percentile) reported 10 times more LBP injuries (19 out of 259) than the "most fit" (highest 16 percentile; 2 out of 266). However, the most fit group reported more serious LB injuries, which the authors attributed to the overexertion in training and task performance exhibited by very-fit individuals (Cady et al., 1979). Concerns have been raised concerning the interpretability of the results of this study (McQuade et al., 1988; Plowman, 1994), since the individual effects of the components constituting the composite fitness score are not addressed, physical work capacity was presented as watts rather than in terms of $\dot{V}O_2$ max, and the mean age difference between the most fit and least fit group was not accounted for and focused only on acute injuries.

In a more recent cross-sectional study, Suni et al. (1998; 437 men and 389 women) used a health-related fitness assessment to determine whether individuals with low, mid, and high levels of physical fitness differ in their perceived health, mobility, and back function. Back function and symptoms were assessed by subjective questionnaires. Subjects were categorized into least fit 20% (low), next 40% (mid), and remaining 40% (high) fitness group on each of the fitness tests. Men and women with mid $\dot{V}O_2$ max fitness and women with high $\dot{V}O_2$ max fitness were associated with "good perceived back function" and with "seldom experiencing back pain." Unfortunately, ranges for $\dot{V}O_2$ max were not provided for comparison with other studies. Contrary to these studies, cardiovascular fitness, defined by oxygen uptake on a submaximal treadmill test ($\dot{V}O_2$ max) neither discriminated between those with and without LBP on initial testing nor predicted future LBP during a 4-year follow-up of 2,434 Boeing manufacturing employees (Battie et al., 1989a). Although McQuade et al. (1988) found a weak relationship between aerobic capacity and measures of chronic LBP, overall fitness, a composite of physical work capacity, strength, and flexibility accounted for 23% of the variability in dysfunction.

It is difficult to draw definite conclusions on the effects of physical activity, as there is inconsistency in the method of reporting duration and frequency of participation. However, a number of studies indicated that high levels of excessive sport activity/exposure lead to increased risk of LBP, while an equal number suggest an increase in lifestyle activity lead to reduced LBP. Only the Saraste and Hultman (1987) study reported no differences. It may be that while some physical activity is beneficial, too much may be a potential risk factor for LBP development as proposed by the dose response curve in the CPAFLA. Despite concerns over protocol and units of measurement, physical fitness has been shown to both predict future LBP in prospective studies and distinguish between health and LBP individuals in retrospective surveys. Given the somewhat contradictory results, it is not surprising that Plowman (1994), in a recent review, identified the association of physical activity/fitness with LBP development as a "fertile area for research" (p. 224).

Musculoskeletal fitness and back pain. The importance of musculoskeletal fitness components (muscular strength, flexibility, and endurance) as factors in LBP prevention has been widely speculated and has led to inclusion of their testing in many research test batteries and tests of physical fitness (Plowman, 1994). The flexibility, strength, and endurance of the musculature involved in trunk motions have all been subjected to retrospective and prospective investigations, determining their discriminatory or predictive abilities. The mechanics of trunk flexion

and extension are well understood; however, it is not clear what component of the muscles are the best descriptors of LBP development. Hamill and Knutzen (1995) and Plowman (1994) provide a detailed anatomical account of trunk flexion. A brief synopsis is provided here to highlight the involved musculature. Specific research findings and associated assessment protocols will be addressed under the separate headings of flexibility, strength, and endurance. A summary of the studies and their associated findings are presented in Tables 2 and 3.

From a standing position, forward flexion of the trunk is initiated by the iliopsoas muscle along with the abdominals (which also serve to increase the intra-abdominal pressure). The contraction of the oblique muscles and the transverse abdominus together with the intra-abdominal pressure provide support to the low back, thereby reducing the eccentric activity required of the erector spinae musculature. There is an increase in the erector spinae activity as the lumbar portion of trunk flexion is completed (approximately 45–50% of trunk flexion (Nordin and Frankel, 1989). Trunk flexion then continues as a result of anterior pelvic tilt, which is controlled by the eccentric contractions of the hamstrings and gluteus maximus. At this point there is no activity of the erector spinae, and the motion is

Table 2 Summary of Studies Which Included Trunk and Hamstring Flexibility Tests in Their Assessment of LBP

		N	Trunk and Hamstring Flexibility Tests			
			Schober-L	SLR	S&R	Toe Touch
Prosp	Bergquist-Ullman and Larsson (1977)	217	X	X		
Prosp	Troup et al. (1981)	774 (M)	X	X*		
Prosp	Biering-Sørensen (1984b)	442(M) 478(F)	X*	X		X X*
XS	Pope et al. (1985)	321(M)	X	X		
XS	McQuade et al. (1988)	50(M) 46(F)		X X		
Prosp	Battié et al. (1989b)	2350 (M) 670 (F)		X* X*		
Prosp	Battié et al. (1990)	2350 (M) 670 (F)	X X		X X	
XS	Tafazzoli and Lamontange (1996)	18 (M)		X		X*
XS	Payne et al. (2000)	233(M) 287(F)			X* X*	

*Represents significant difference at $p < .05$ level. M = male; F = female; Prosp = prospective study; XS = cross-section study. SLR = straight leg raise; S&R = sit & reach test.

Table 3 Summary of Studies Which Included Strength Measurements in Their Assessment of LBP

	Study	N	Isometric Trunk Strength			Abdominals		Quadriceps		Isometric Back Endurance	
			Flexion	Extension	Ext/Flex	Sit-up	Curl-Up	Strength	Endurance	Beiring-Sørensen	%MVC
XS	McNeill et al. (1980)	52(M)	X	X*	X*						
Prosp	Troup et al. (1981)	45(F)	X	X*	X*						
		774(M)				X*					
XS	Suzuki & Endo (1983)	28(F)				X*					
		442(M)	X*	X*	X	X				X*	
Prosp	Biering-Sørensen (1984b)	478(F)	X	X	X	X				X*	
XS	Pope et al. (1985)	321(M)	X*	X	X						
XS	Jørgensen & Nicolaisen (1985)	53(M)	X	X	X					X*	X*
XS	Nicolaisen & Jørgensen (1987)	24(M)	X	X	X					X*	X*
XS	McQuade et al. (1988)	53(F)	X	X	X					X	X
		50(M)							X	X	X
		46(F)									
XS	Burton et al. (1989)		X*	X*							X*
XS	Holmstrom et al. (1992)	140(M)	X	X	X*						X
XS	Alantra et al. (1994)	242(M)	X								X
		233(F)	X								
XS	Sumi et al. (1998)	245(M)									X*
		253(F)									X*
XS	Ashmen et al. (1999)	36(M)									X*
Prosp	Stevenson et al. (in press)	110(M)							X*	X*	X
XS	Payne et al. (2000)	39(F)							X*	X*	X
		233(M)									X*
		287(F)							X*	X*	X*

*Represents significant difference at $p < .05$ level. M = male; F = female; Prosp=prospective study; XS= cross-section study

restricted by gluteal and hamstring flexibility. The mechanical and anatomical sequence is reversed to extend the trunk from a flexed position. This combination of lumbar spinal flexion and hip flexion is sometimes called lumbo-sacral rhythm (Nelson et al., 1995).

Flexibility. The spine's range of motion (ROM) has been reported to be one of the most functional measures in a clinical setting (Burton, 1997; Mayer et al., 1985). There are a number of clinical tests used to assess hamstring and low back flexibility, including the inclinometer, goniometer, flexiometer, tape measure, flexicurve, and x-rays. The sit and reach (S&R) and toe touch tests are frequently used to assess both back and hamstring flexibility, the modified Schober test to measure back flexibility, and the straight leg raise (SLR) to measure hamstring flexibility. The S&R test has been described earlier with respect to the assessment test included in the CPAFLA, and the toe touch test is simply a modification of the S&R in a standing rather than a seated posture. The Schober test has been modified to measure lumbosacral flexibility (Schober-L) and combined thoracic and lumbar flexibility (Schober-L+T). In the Schober-L protocol, three marks are placed on the patient while standing in an erect position. An anatomical reference mark is made on the lumbosacral joint with subsequent marks placed 5 cm above and 10 cm below the lumbosacral joint mark. The distance between the marks is therefore 15 cm and considered the base line. The subject then flexes forward maximally. Trunk flexion is measured as the distance between the two marks minus the original 15 cm baseline distance. The Schober-L+T test is conducted in the same manner with markings on the spine at the level of the posterior superior iliac spine and the C7 spinous process. The SLR test is conducted with the patient lying on his/her back ensuring the lower back is flat on the table. With knees extended, the leg is slowly raised until the examiner feels sufficient resistance to the motion. The angle of the extended leg with respect to the hips is measured with a goniometer to the nearest degree. The test is conducted on each leg separately.

Although a number of clinical tests are used to evaluate hamstring and trunk flexibility, the relationship of these factors to LBP are somewhat unclear. Anatomical considerations indicate that tightness in the hamstrings can result in increased low back strain during trunk flexion motions from standing (Tafazzoli and Lamontagne, 1996) and seated postures (Stokes and Aberly, 1980). Troup et al. (1981) conducted two 12-month follow-up investigations of 802 industrial workers who initially suffered from episodes of LBP. They found restrictions of 15 degrees or more unilaterally on the SLR test, which provided predictive value for recurring LBP in the first year of follow-up. Battié et al. (1989a) reported a similar prognostic value using the SLR test in a prospective study of 3,020 manufacturing employees. In other studies, hamstring tightness has failed to distinguish between healthy and LBP individuals (Pope et al., 1985; Stevenson et al., in press; Tafazzoli and Lamontagne, 1996), and it was not able to predict first-time experience or recurrence of LBP (Biering-Sørensen, 1984a).

The relationship between trunk flexibility and LBP remains unclear. For example, Tafazzoli (1996) found that trunk flexibility, measured with the toe-touch test, was significantly lower in men with LBP. This finding has received sufficient support in the literature (Burton et al., 1989b; Mellin, 1986, 1987; Troup et al., 1987) including a recent study of 520 Canadians aged 15 to 69 years old (Payne et

al., 2000), which reported lower trunk flexion scores on the S&R test for individuals identified as having a history of LBP. In contrast, Biering-Sørensen (1984a) suggested that men with hypermobility in their back are more susceptible to LBP. The opposite trend was true for women. Trunk flexibility results from the Schober-L and S&R tests were unable to predict the 279 out of the 3,020 Boeing aircraft-manufacturing employees who reported LBP over a 4-year examination period (Battié et al., 1990). Other prospective (Bergquist-Ullman and Larsson, 1977; Troup et al., 1981) and cross-sectional studies (Moore et al., 1991) have been unable to report a relationship between trunk flexion and LBP.

The Schober, S&R, SLR, and toe-touch test have all been shown to be highly reproducible with interrater reliability correlations ranging from 0.95 to 0.99 (Jackson and Baker, 1986; Jackson and Langford, 1989; Jackson et al., 1998; Kippers and Parker, 1987; Nachemson and Bigos, 1984; Simoneau, 1998). This proven reliability, added to the fact that the tests are easy to administer, makes them attractive for use in physical assessment batteries. However, concerns have been raised over the criterion-related validity of some of the tests. For example, the S&R test is administered to assess trunk and hamstring flexibility. It has been shown that S&R performance is much more closely related to hamstring than trunk flexibility. Jackson and Baker (1986) reported that S&R performances by 100 young women (13 to 15 years old) were related moderately to hamstring ($r = .64$) and less so to trunk flexibility ($r = .28$). When the previous study was replicated with adult women and men, Jackson and Langford (1989) found a correlation between the S&R test and hamstring flexibility to be .89 and .70 for men and women, respectively. The correlation with low back flexibility (Schober test) was 0.12. As a result of these low correlations, the author conducted a stepwise regression analysis, which revealed that once hamstring flexibility entered the equation for predicting S&R score, trunk flexibility increased the shared variance by a mere 0.03. In an evaluation of five tests of flexibility, Simoneau (1998) found the S&R test to be moderately correlated with the SLR test (0.78, $p < .01$), moderately and negatively correlated the Schober-L+T test ($-.42$, $p < .01$) and poorly related to the Schober-L test ($-.26$). These findings provide additional strength to the argument that the S&R test is predominately a test of hamstring flexibility. It is also interesting to note that anthropometric measurements had little impact on S&R performance outcomes. Jackson et al. (1998) concluded that the S&R test lacks criterion-related validity with LBP for inclusion in health-related fitness tests based on a poor correlation ($r = -.012$) in a cross-sectional sample of 2,747 subjects.

The SLR and Schober tests are less controversial than the S&R test with respect to criterion-related validity. The major concern with these tests, as with any clinical test, is a strict adherence to consistent protocols. In the SLR, care should be taken to insure that the pelvis is completely stabilized providing a true indication of hamstring length (Tafazzoli and Lamontagne, 1996). With the Schober test, an expected error for an inexperienced tester would be the proper location of the spinal landmarks. Macrae and Wright (1969) suggest that errors in measurement of up to 2 cm result in a flexion error of only two degrees.

Although the Schober, S&R, and toe touch tests are the most common static test of spine flexibility, several other have been used, including X-rays (Chiou et al., 1996; Dvorak et al., 1991), goniometers, inclinometers (Mayer et al., 1984), skin distraction (Moll and Wright, 1971), and photometric techniques (Gill et al.,

1988). Excluding X-ray and photometric techniques, static ROM tests are simple and inexpensive to administer; however, dynamic ROM variables have been reportedly more sensitive in the identification of LBP (Marras and Wongsam, 1986). Higher order kinematic derivatives, velocity, and acceleration have been demonstrated to be a better discriminate of LBP than static ROM (Marras et al., 1993a). Various techniques have been used to acquire dynamic spinal ROM including cinematography (Kumar, 1974), videography (Marras and Mirka, 1992) opto-electric motion tracking (Gracovestsky et al., 1990), and more recently isokinetic dynamometry (Masset et al., 1993), electronic goniometers (Boocock et al., 1994), and triaxial electrogoniometers (Marras et al., 1993a).

In 1986, Marras and Wongsam introduced a functional trunk velocity test, whereby the subject standing feet shoulder width apart and arms crossed over the chest is instructed to flex and extend the trunk as fast as possible while continuing to maintain his/her balance. In subsequent studies, Marras and colleagues found the peak velocity and acceleration profiles were able to discriminate between healthy and LBP sufferers (Marras et al., 1993a, 1995, 1993b; Marras and Sommerich, 1991), leading to the publication of a database of normal trunk kinematics based on 351 healthy subjects (Marras et al., 1994). Marçal (1999) found significant thoracic, thoracolumbar, and sacral kinematic differences between severe, moderate, and healthy LBP groups while performing the trunk velocity test. The studies of Marras and colleagues and Marçal incorporate devices (the Lumbar Motion Monitor and Pohemus Fastrak™), which have demonstrated good reliability in measuring lumbar spine kinematics (An et al., 1988; Marras and Sommerich, 1991; Percy and Hindle, 1989); however, they are expensive and require a certain degree of technical experience to operate, eliminating them as practical assessment tools for general fitness assessment batteries. In light of the encouraging predictive ability of the trunk velocity test, future efforts should be directed at determining criterion values from a strictly temporal sense for distinguishing a healthy trunk velocity. The establishment of a temporal-related criterion measure would eliminate the need for the expensive hardware required presently to assess trunk velocity, therefore making the test practical for general fitness appraisals such as the CPAFLA.

Strength. An association has been suggested between weakness in the trunk extensor muscles, the major stabilizers of trunk posture and controllers of forward flexion, and LBP development. McNeill et al. (1980) compared isometric trunk extension and flexion strength, in a standing position, between males and females with and without LBP. Low back pain patients were more limited in their ability in trunk extension than flexion with higher relative extension strengths being reported for healthy males and females. On average, the male LBP group developed 80% and 55% of the flexion and extension strengths of their healthy counterparts. For the females, the corresponding strength values were 65% and 45%, respectively. Similar strength differences between healthy and LBP sufferers were found when strength testing was conducted in a standing position (Holmström et al., 1992), similar to McNeill et al. (1980), and in a prone position with resistance applied against a Cybex dynamometer attachment (Suzuki and Endo, 1983). Other studies have suggested, however, that trunk strength measures have no prognostic value for either subsequent development of LBP (Biering-Sørensen, 1984a, 1984b;

Nicolaisen and Jørgensen, 1985; Riihimaki et al., 1989a; Thorstensson and Arvidson, 1982) or first time LBP development (Biering-Sørensen, 1984a; 1984b). Only one study has found that decreased trunk muscle strength lead to LBP when job requirements were taken into consideration (Chaffin et al., 1978).

The relationship with trunk muscle strength and LBP has also been suggested to be exclusive to flexion strength (Pope et al., 1985) or extensor strength (Riihimaki et al., 1989a) but not both. The balance between the flexion and extension strength has been reported as a ratio of extensor to flexor strength; however, its importance is not well established. The trunk extensors are typically found to be 30% stronger than the flexors, indicating an average extension/flexion strength ratio of 1.3 (Beimborn and Morrissey, 1988; Holmström et al., 1992; Mayer et al., 1985; McNeill et al., 1980; Nicolaisen and Jørgensen, 1985). Significantly lower extensor/flexion ratios have been cited between healthy and chronic LBP sufferers in a college student and hospital employee population (McNeill et al., 1980) and a population of construction workers (Holmström et al., 1992). Other authors did not report a significant reduction in the trunk muscle strength ratio of individuals with LBP (Biering-Sørensen, 1984a; Suzuki and Endo, 1983).

The above-mentioned studies have assessed isometric trunk musculature strength by requiring the subjects to flex or extend the trunk against an instrumented strap (e.g., strain gauge, load cell, dynamometer) while either lying on a table or standing upright. All the studies differed slightly in the testing protocol and the apparatus used; however, not one provided a reliability estimate for their chosen protocol. Moreland et al. (1997) compared the inter-rater reliability of two tests of trunk extensor and flexor musculature. In the first test, designed to assess abdominal isometric force, the subject lays on a table resting his/her back and head on a 30 degree wedge placed at the head of the table. A therapist held a MicroFET dynamometer 2.54 cm below the sternal notch of the subject. The therapist was required to resist the subject's motion while preventing motion of the dynamometer, performing a "make test." With his hands on his abdomen and knees bent at 90 degrees, the subject curled up to the point of lifting the scapulae from the wedge, exerting maximum force against the dynamometer. The second test examined extensor isometric force. The subject was positioned in the Biering-Sørensen back endurance test position, prone over an examination table, and the lower legs and hips fastened to the table by belts. With the arms placed across the chest, the subject was instructed to hold the trunk in a neutral position exerting maximum force against the dynamometer, which was held at the level of the inferior angle of the scapula. The reported interclass correlations were low (abdominal isometric test = 0.25, extensor isometric test = 0.24) for these tests. The reliability of "make tests" lies in the tester's ability to apply sufficient force to resist the subject's movement. Moreland et al. (1997) indicated that one of the raters reported substantially lower test results than the other two raters, which may have significantly affected their reported reliability.

The association of trunk strength measures is not well established. There seems to be some usefulness in the extension/flexion ratio as it normalizes strength with respect to the individual. The evaluation of strength measures also suffers from large variations in performance capacity of LBP subjects and the level of motivation of healthy and LBP subjects (Alaranta et al., 1994; McNeill et al., 1980).

Lower strength values recorded by back pain sufferers may be attributed to both limitations induced by actual back pain and the anticipation of pain associated with the strength test.

Endurance. Trunk extension endurance is typically measured using a method introduced by Hansen (Pope, 1989) and later modified by Biering-Sørensen (1984a), whereby the subject lies prone on a table positioned so that the end of the table is even with the iliac crests. With the hands behind the head and the legs stabilized with straps to the table, the subject is required to maintain a neutral position of the upper body. Endurance is measured as the time for which the upper body, estimated to be a workload of approximately 55% of maximal voluntary contraction (Smidt and Blanpied, 1987), can be supported. An alternate method of testing back endurance is the length of time a subject can sustain a 60% MVC extensor contraction of the trunk muscles against a dynamometer in a standing position (Dolan et al., 1995; Jørgensen and Nicolaisen, 1987; Nicolaisen and Jørgensen, 1985).

Suni et al. (1998) found that low fitness in static back extension (unfortunately the range of extension time was not reported) was systematically associated with back dysfunctioning and pain in both genders, a finding consistent with other cross-sectional studies (Ashmen et al., 1999; Holmström et al., 1992; Jørgensen and Nicolaisen, 1987; McQuade et al., 1988; Payne et al., 2000). Many prospective studies have indicated that good isometric trunk endurance seems to prevent first-time experience of LBP in men (Biering-Sørensen, 1984a, 1984b; Nicolaisen and Jørgensen, 1985) and women (Nicolaisen and Jørgensen, 1985) whereas trunk endurance was not able to predict future mild LBP in an industrial population (Stevenson et al., in press).

The Stevenson et al. (in press) findings highlight an interesting factor about the Biering-Sørensen test in that they did report a relationship between median frequency EMG during this test and the development of LBP. In other words, those individuals who could not sustain the extension position, had high median frequency intercepts, and had faster rates of decline indicating fatiguing of back erector spinae musculature were more apt to develop mild LBP. Mannion and colleagues (Dolan et al., 1995; Mannion and Dolan, 1994) found that the fatigue ratios of back erector spinae as determined by median frequency EMG could predict total endurance time. She pointed to the main weakness of the Biering-Sørensen test whereby subjects needed to be encouraged strongly to go to maximal fatigue or they were apt to stop the test early. Using EMG, one could determine true fatigue more accurately with a greater degree of repeatability (Moffroid et al., 1993; Roy et al., 1989).

Subject motivation and differences in protocol are factors influencing the reliability of the endurance test. Biering-Sørensen (1984a) tested a male subject five times over a 10-day period and reported a coefficient of variation of 7%. Reliability coefficients have reportedly ranged from as low as 0.59 (Moreland et al., 1997) to 0.63 (Alaranta et al., 1994) to as high as 0.89 (Jørgensen and Nicolaisen, 1987) and 0.91 (Holmström et al., 1992), with LBP sufferers performing with a higher degree of variability (Alaranta et al., 1994). Table 4 identifies the variability in the mean endurance times reported across studies. Biering-Sørensen (1984a) reported the highest mean endurance times of nearly 200 s with more than 44% of

the times being greater than 240 s. A maximum of 240 s has been suggested for this test since it is felt that time above this represented healthy individuals (Sunii et al., 1998). The majority of the studies listed in Table 4 had mean values far below 240 s (Alaranta et al., 1994; Holmström et al., 1992; McQuade et al., 1988; McGill et al., 1999; Payne et al., 2000), therefore substantiating this upper limit. It should be noted, however, that two studies reported average performed times well above 240 (Jørgensen and Nicolaisen, 1987; Nicolaisen and Jørgensen, 1985). The method of support for the lower extremity may have a role in the different values. The studies in which the subjects were supported by two or three straps (Biering-Sørensen, 1984a; Jørgensen and Nicolaisen, 1987) tended to report higher values than those where subjects were supported by a strap around the ankles or by the evaluator holding the legs down. Depending on whether the test was conducted on a cushioned table or not may also affect the level of comfort for the subject and hence the length of the test.

There seems to be sufficient support for including a measure of back endurance in an assessment of back fitness. Although using EMG and the median frequency rate of decline would be the most reliable measure for insuring an accurate assessment of fatigue, the endurance time provides a practical alternative for use in a general fitness test battery.

Recommendations for the Enhancement of the Current CPAFLA

Payne et al. (2000) conducted a study aimed at examining the relationship between back pain history and measurements of physical activity participation and health-related fitness for use in the CPAFLA. They included in their measurements the curl-ups and S&R tests, waist girth (WG), the Healthy Physical Activity Questionnaire, and the Biering-Sørensen trunk endurance test. All measurements, excluding the Biering-Sørensen test, are currently collected as part of the CPAFLA, but only the curl-ups and S&R are used in back health assessment. The authors' final recommendations were that the CPAFLA continue to administer the curl-ups and the S&R test and that these tests should be augmented with the inclusion of back extensor endurance, physical activity participation, and WG assessments.

The authors of this paper are in agreement with recommendations set forth by Payne et al. (2000) as components to be included in the CPAFLA but wish to expand upon these and make further recommendations. Not only is natural history of low back pain development of complex and multidimensional etiology, it is a problem that is individually driven. That is, the complement of risk factors which lead one individual to an episode of LBP leaves another entirely pain free. To capture this diversity requires a composite of variables, which combined together, provide a more robust evaluation of a potential predisposition to a back health risk. However, the development of a composite score based on identified risk factors requires researching to determine the appropriate weighting of each factor. It is currently not known whether low back extensor endurance is more or less important than maintaining strong abdominal muscles. The challenge of future research is to include the recommended variables in their assessment of back fitness to determine individual factor weightings through regression analyses. The following

Table 4 Mean Trunk Endurance Time in Seconds Based on the Biering-Sørensen Protocol

	No Lower Back Pain			Lower Back Pain			Leg Support
	Males	Females	Combined	Males	Females	Combined	
Biering-Sørensen (1984b)	198	197		163	177		2 straps, buttocks & legs
Nicolaisen & Jørgensen (1985)	184 [59]	219 [33]		148 [61]	146 [62]		3 straps, buttocks, knees & ankles
Jørgensen & Nicolaisen (1987)	184 (70-240)			148 (45-240)			3 straps, buttocks, knees & ankles
McQuade et al. (1988)	171.5			137.5		35.1	indicated legs stabilized
Holmström et al. (1992)	(119-266)			(21-253)			2 straps, buttocks & legs
Alantra et al. (1994)*	101			98	89		1 strap, ankles
Moreland et al. (1997)	(54-56)						2 straps, hips & below knee
McGill et al. (1999)	146 [51]	189 [60]	171 [60]				2 straps, mid-thigh, below-knee
Payne et al. (2000)*	112.8 {4.1}	117.2 {4.8}		77.5 {9.5}	92.5 {9.3}		evaluator held calves

Note. Reported ranges, standard deviations or standard errors of the mean are provided in round brackets (), square brackets [] and curly brackets { }, respectively.

*Provide a breakdown by age categories.

paragraphs outline the factors that should be considered for inclusion in the CPAFLA and provide a brief discussion on areas requiring additional research consideration.

The measurements for abdominal strength (curl-ups), trunk & hamstring flexibility (S&R), WG, and physical activity participation have sufficient empirical evidence to support their inclusion in the CPAFLA. Since these measures are already administered in the CPAFLA they do not represent an addition to the Certified Fitness Consultant's (CFC) training nor do they add to the time required to complete an assessment. Although the authors support the inclusion of the S&R test, more research is required to delineate the muscular component(s) being evaluated. The literature to date suggests a stronger association with hamstring flexibility than trunk flexibility. This information is important for correct interpretation of results leading to an effective client prescription by the CFC. If a true test of trunk flexibility is desired, an alternate test may be required. Research efforts should continue to be directed toward determining the best flexibility measurement for the assessment of back health.

The trunk endurance test has received strong support in the literature as a physical measure of back fitness. Although this would be an addition to the current CPAFLA protocol, it can be done with minimal interruption to the existing procedure. The Biering-Sørensen test is ideal for a general fitness assessment, as it requires little in the way of equipment, time, and training. Traditionally the test is conducted on a plinth with straps to secure the client to the table. To limit the amount of new equipment needed, the steps used for the modified Canadian Aerobic Fitness Test (mCAFT) can replace the plinth, as was done by Payne et al. (2000). A comfortable mat should be placed on the surface of the top step to provide adequate cushioning for the client. Additional padding should be placed at the level of the pelvis to reduce discomfort, as clients will be required to lie prone on the steps. Velcro straps should be added to secure the client's lower body to the step. Pilot work will be required to determine the placement of the straps along the top step. The slot for the straps must allow adjustment, in order to accommodate various body sizes. Three straps should be used for support, one at the level of the ankles, one on the calves below the knees, and a third on the legs below the buttocks. The use of straps will reduce the pressure placed on the knees when the examiner holding the ankles provides the support. There has been some debate over the length of time for which to administer the test. Since studies have reported endurance time in excess of 240 s, when two or more support straps are used, the recommendation at this time is to conduct the endurance test to a maximum of 240 s indicating an excellence score. In order to score the endurance test, normative data is required to provide appropriate levels of back risk. Until this data is collected and published, the population ranges recently recorded by Payne et al. (2000) can be used to represent the CPAFLA levels of fitness. It is understood that the Biering-Sørensen test can be affected by client motivation, and therefore the role of the CFC as a motivator must be outlined. It is recommended that the CFC should motivate the client in order to obtain the most accurate representation of the client's trunk endurance capabilities.

Lifestyle and psycho-social factors play a large role in individual health, including back health. The literature is rich with support for the adverse effects of poor lifestyle choices and psycho-social factors with respect to LBP development. Many of the suggested concerns are listed in Table 1 and discussed in various

sections in the review. The current CPAFLA contains the FANTASTIC Lifestyle Checklist that addresses many of the more pertinent lifestyle and psycho-social factors identified with LBP such as smoking, alcohol use, nutrition, social support, and job satisfaction. To use this checklist as a measure of back health would require validation research. It is felt that research would be better suited to develop a new questionnaire, which incorporates some of the FANTASTIC items with more focus on back health and fitness in general. The development of such a questionnaire may combine items from various workplace and lifestyle questionnaires already used to evaluate LBP in ergonomic research studies. Future research is required to develop and validate such a questionnaire within the CPAFLA, making this a recommendation for future revisions of the appraisal.

As with any assessment tools based on scientific literature, there is a need to continually monitor the state of research. The methods of assessing trunk endurance and trunk motion are two areas that have reported significant advancements in the past number of years. The assessment of trunk fatigue continues to be improved with the inclusion of EMG monitoring and the determination of the spectral properties of the musculature. The prediction of endurance time for the median frequency slope has been proposed. The technology for collecting EMG has produced more compact EMG units for a lower cost. In the not-so-distant future a small EMG unit could be placed on the back muscles and provide fatigue data as quickly and easily as reading a hand-held dynamometer for grip strength. The work of Marras and colleagues (1986) and more recently Marçal (1999) has demonstrated the ability to differentiate between healthy and LBP sufferers using a trunk velocity protocol. The groups showed significant differences in their flexion and extension velocity at both the lumbar and thoracic level of the trunk. At this time the motion is captured using expensive equipment that is not feasible for a general fitness appraisal. If, however, the relationship between the research findings can be expressed by as simple measure as the time to complete the velocity test, this would provide an assessment of total trunk motion.

In conclusion, it is recommended that the back health be assessed using the following measurements: curl-ups, S&R, WG, Biering-Sørensen trunk endurance test, and the Healthy Physical Activity Questionnaire. At this time, each score is considered to have equal weighting and therefore assessed on an individual basis, as is the current procedure with the curl-ups and S&R tests. The immediate goal of future research is to determine the weighting factors for each of the components and development of a composite score, which would better reflect back health risk. The inclusion of a lifestyle and psycho-social questionnaire should be considered once developed and validated within the context of the CPAFLA.

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