Université de Montréal

Fidélité et validité de la mesure clinique du déjettement du tronc auprès d'enfants et d'adolescents présentant une scoliose idiopathique.

par

Erin Grunstein

École de Réadaptation

Faculté de Médecine

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Ce mémoire intitulé :

Fidélité et validité de la mesure clinique du déjettement du tronc auprès d'enfants et d'adolescents présentant une scoliose idiopathique.

Présentée par :
Erin Grunstein

a été évaluée par un jury composé des personnes suivantes :

Dorothy Barthelemy, président-rapporteur
Debbie Feldman, directeur de recherche
Stefan Parent, co-directeur
Nathaly Gaudreault, membre du jury

Résumé

La mesure du déjettement du tronc est un élément important pour évaluer la posture en ce qui a trait à la scoliose idiopathique. Cependant, il y a peu d'informations quant à sa mesure et les associations entre le déjettement du tronc et d'autres indicateurs ou facteurs pertinents. Les objectifs de cette étude sont : 1) d'évaluer la validité et la fiabilité de test-retest du fil à plomb pour mesurer le déjettement du tronc de C7 à S1 chez les personnes atteintes de scoliose idiopathique; et 2) d'étudier l'association entre le déjettement du tronc et les facteurs suivants : la douleur, l'angle de Cobb, le type de scoliose, la santé mentale et l'image de soi chez les personnes atteintes de scoliose idiopathique.

Nous avons recruté 55 sujets âgés de 10 à 21 ans atteints de scoliose idiopathique (angle de Cobb : 15º à 60º) de la clinique de scoliose dans un hôpital pédiatrique de soins tertiaires. Le déjettement a été mesuré directement sur les sujets à deux reprises par la même physiothérapeute de même que sur les radiographies prises ce jour-là. Deux mesures ont été prises à chaque fois : une les pieds joints (FT) et l'autre en écartant les pieds (FA). Les sujets ont répondu au questionnaire adressé au patient de la Scoliosis Research Society-22, qui traite de la douleur, de l'image de soi et de la santé mentale. Le type de scoliose et l'angle de Cobb ont été mesurés sur les radiographies prises ce jour-là. Nous avons utilisé la théorie de la généralisabilité pour calculer la fidélité de test-retest pour les mesures FT et FA, en rapportant les coefficients de fiabilité (f) et les erreurs types de mesure (SEM). La validité de la mesure du fil à plomb a été calculée en comparant les mesures prises directement sur les radiographies en utilisant le coefficient de corrélation de Pearson. Les corrélations de Pearson ont été calculées entre le déjettement du tronc et la douleur, l'angle de Cobb, l'image de soi et la santé mentale. Les corrélations de Spearman ont été calculées entre le déjettement du tronc et le type de scoliose. Nous avons ensuite utilisé des modèles de régression linéaire multiple pour déterminer les associations entre ces variables.

Nos résultats indiquent que les mesures de déjettement du tronc en utilisant un fil à plomb ont une forte corrélation ($r = 0{,}87$) avec la mesure obtenue par radiographie. La mesure du déjettement du tronc en utilisant un fil à plomb a démontré une excellente fidélité de test-retest (f: 0,98 pour la mesure FT et 0,99 pour la mesure FA) et les SEM étaient de 2,0 mm pour la mesure FT et 1,8 mm pour la mesure FA. Le déjettement du tronc est corrélé positivement avec l'angle de Cobb ($r = 0{,}32$, $p = 0{,}02$), mais il n'est pas corrélé à la douleur, la santé mentale, l'image de soi ou le type de scoliose.

Les conclusions de notre étude ont montré que la mesure clinique du déjettement du tronc en utilisant un fil à plomb est une méthode fiable et valide et que le déjettement du tronc est associé à l'angle de Cobb. Une étude longitudinale est nécessaire pour déterminer si le déjettement du tronc est un indicateur pronostique de la progression de la scoliose.

Mots-clés: la scoliose idiopathique, le déjettement du tronc, fil à plomb, posture, déplacement latéral du tronc

Abstract

Measurement of trunk list is an important component of an evaluation of posture in idiopathic scoliosis. However, there is little information regarding its measurement and the associations between trunk list and other relevant indicators or factors. The objectives of this study were to: 1) evaluate the validity and test-retest reliability of the plumbline to measure trunk list from C7 - S1 in persons with idiopathic scoliosis and 2) to explore the association between trunk list and the following factors: pain, Cobb angle, type of scoliosis, mental health and self-image, in persons with idiopathic scoliosis.

We recruited 55 participants aged from 10 to 21 years old with idiopathic scoliosis (Cobb angle: 15º to 60º) from the scoliosis clinic at a tertiary care pediatric hospital. Trunk list was measured directly on participants on two occasions by the same physiotherapist and also on radiographs taken that day. Two measurements were taken each time: with feet together (FT) and feet apart (FA). The participants answered the Scoliosis Research Society-22 patient questionnaire, which addresses pain, self-image and mental health. Type of scoliosis and Cobb angle were measured on radiographs taken that day. We used generalizability theory to calculate test-retest reliability for FT and FA, reporting Dependability Coefficients (f) and Standard Errors of Measurement (SEM). Validity of the plumbline measurement was calculated by comparing to measurements taken directly on radiographs using the Pearson correlation coefficient. Pearson correlations were calculated between trunk list and pain, Cobb angle, self-image and mental health. Spearman correlations were calculated between trunk list and type of scoliosis. We then used multiple linear regression models to determine associations between these variables.

Our results indicated that the plumbline measurements of trunk list correlated highly (r=0.87) with the measure obtained via radiograph. Plumbline measurements of trunk list demonstrated excellent test-retest reliability (f: 0.98 for FT and 0.99 for FA) and SEMs were 2.0 mm for FT and 1.8mm for FA. Trunk list was positively correlated with Cobb angle (r=0.32, p=0.02) but it was not correlated with pain, mental health, self-image, or type of scoliosis.

The conclusions of our study were that the clinical measurement of trunk list using a plumbline is both reliable and valid and that trunk list was associated with Cobb angle. A longitudinal study is needed to determine whether trunk list is a prognostic indicator of scoliosis progression.

Keywords: idiopathic scoliosis, trunk list, plumbline, posture, lateral trunk shift

Table of contents

List of Tables

List of Figures

List of Abbreviations

AIS	Adolescent Idiopathic Scoliosis
ANOVA	Analysis of Variance
CHU	Centre Hospitalier Universitaire
D Study	Decision Study
FA	Feet Apart
FT	Feet Together
G study	Generalizability Study
ICC	Intra-class Correlation Coefficient
IS	Idiopathic Scoliosis
S	Session
P	Person
PH	Photography
PL	Plumbline
r	Pearson Correlation Coefficient
SD	Standard Deviation
SEAS	Scientific Exercises Approach to Scoliosis
SEM	Standard Error of Measurement
SRS	Scoliosis Research Society Outcomes Instrument
SRS-22vf	Scoliosis Research Society Outcomes Instrument 22 – French version
T	Trial
χ^2	Chi-squared
ρ^2	Generalizability Coefficient
ϕ	Dependability Coefficient

Dedicated to my husband, Alex, and my parents for their constant love and support

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Chapter 1: Introduction

Trunk list is a lateral deviation of the spine, frequently seen in individuals with scoliosis, disc herniation and low back pain[1]. It is associated with muscle asymmetry and imbalance[2] and may lead to development of pelvic obliquity, curve progression following skeletal maturity and back pain in individuals with idiopathic scoliosis (IS)[3, 4]. It is an important element of the scoliosis evaluation since it may be predictive of outcome[2, 5, 6] and is routinely measured in a clinical setting using a plumbline and determining the horizontal displacement from midline[7]. When trunk list is mentioned in this thesis, this author is referring to trunk list measured from the C7 to the S1 vertebrae using a plumbline.

Only one study examines reliability of the plumbline used to measure trunk list in persons who do not have IS[8] and none investigate its validity. Therefore, despite its widespread use in the clinical evaluation of IS, little is known about the reliability and validity of the plumbline measure in IS. It may also be important in the context of repeated measures of trunk list over time, which has been suggested as a possible marker of scoliosis progression[2, 5, 6].

Scientific evidence is needed to discern whether trunk list is associated with other aspects of scoliosis, including pain, Cobb angle, type of scoliosis, mental health and self-image. If trunk list is highly associated with Cobb angle and changes over time, then it may serve as a future marker of progression and may have prognostic value when assessing persons with IS. Exploring its relation with pain, self-image and mental health may lead to improved methods of treatment: if trunk list is strongly associated with these factors, then treating trunk list may help improve outcomes. There is very little information regarding the relationship between trunk list and its associations with any of these factors in IS.

The objective of our study was to examine trunk list in individuals with Adolescent IS; namely to investigate the reliability and validity of its clinical measurement using the plumbline and from photographs, and to explore its associations with Cobb angle, type of scoliosis, pain, mental health and self-image.

In this thesis, I will first present the available literature on the subject of trunk list and on adolescent idiopathic scoliosis. In chapter 3, I will define the objectives and hypotheses of my study. In chapter 4, I will outline the methods that were used in our study, including a description of the analysis using generalizability theory. In chapters 5 and 6, I will present the two manuscripts, each of which addresses one of the two objectives described above. Chapter 7 includes some additional results and Chapter 8 comprises a general discussion of all the results presented and clinical implications. The final chapter is a conclusion.

Chapter 2: Literature Review

A review of the available literature regarding trunk list will be presented in this chapter. The definition of trunk list, how it is measured, and its importance in terms of associations with scoliosis, pain and function are discussed. Following this, adolescent IS is examined; first it is described, then classification and types, prognosis, symptoms, scoliosis measurements and evaluation and finally treatment are discussed.

2.1 Trunk List

2.1.1 Trunk List Defined

Trunk list is defined as "the lateral displacement of the human thoracic cage relative to the pelvis" [9]. It is a common trait seen in individuals with postural disorders, including scoliosis, disc herniation and low back pain[9]. Trunk list is also known as coronal balance, lateral translation or deviation of the spine, lumbosacral list and lateral trunk shift.

The percentage of individuals presenting with trunk list in the general population is unknown. In 1941, a study of 395 individuals with scoliosis showed that 55% had a trunk list; 39.5% to the right and 15.5% to the left and that the trunk shift was generally to the side of the convexity. The majority (71%) of the trunk lists were less than or equal to ½ inch or 12.7mm[10]. There is very little information on prevalence of trunk list since that 1941 publication.

2.1.2 Trunk List Measurement

There are various methods to measure trunk list in a clinical setting. These include the plumbline, measurement on radiographs, projecting a shadow from a vertical line, 3D posture analysis systems and digital photography. I will describe these methods in this section.

Trunk list is commonly measured in a clinical setting using a plumbline[7], where the plumbline is placed at a specific spinous process of the cervical or thoracic regions of the spine and the horizontal distance between S1 and the plumbline is measured (see Figure 1). We chose to evaluate trunk list from the C7 vertebrae because it considers all the thoracic and lumbar vertebrae affected by a scoliosis curve. This simple method has not been studied in depth and there is a dearth of knowledge with regards to its psychometric properties and trunk list in individuals with IS.

Figure 1*: Trunk list measured using a plumbline*

There is no reported gold standard for measuring trunk list. Studies use radiographs to evaluate trunk list[11-13], however on radiographs the central of the vertebral body is the landmark used, not the spinous process. It is not practical to take radiographs of all patients in a clinical setting, nor is it safe to expose them to unnecessary radiation. There are various other methods to measure trunk list, however, many of them require expensive equipment that is not widely available and are therefore not feasible in a clinical setting. These methods include:

1.Projected shadow from a vertical wire onto the skin of the back[8]. This method is relatively simple but requires a wire and special lighting to attain a shadow. It is also not portable like a plumbline.

2.3D posture analysis systems, including the 3SPACE Isotrak, measure the three-dimensional shape of the back[14]. However, due to the system requirements (e.g.: special software and equipment), this is difficult to use in a clinical setting.

3.Using digital photography, Fortin et al. developed a computer software program to evaluate posture. Photos are taken of individuals and they are analyzed using this software. Reliability was excellent with a dependability coefficient of 0.95[15]. They found good concurrent validity for trunk list measurement from digital photographs with radiographs among individuals with IS ($r = 0.76$)[16]. Digital photography is a promising method to evaluate posture[17]. However, the tool is not yet widely available and it is more time consuming to use than the plumbline.

McLean and colleagues compared three methods of assessing trunk list: plumbline, projected shadow and 3SPACE Isotrak, a 3D posture analysis system. They demonstrated that the plumbline and projected shadow yielded similar results, yet they selected the plumbline as the preferred method due to its simplicity[8]. This study had several important limitations. First, the number of participants was quite limited, varying between 7 and 27 for the different methods. Second, the trunk list measurement was performed between the T12 and S1 vertebrae, instead of between the C7 or T1 and S1 vertebrae, not accounting for the thoracic spine posture and the increased sway that may have been present at the upper back due to a larger distance from the base of support.

In order to measure trunk list, the spinous processes used as reference points should be identified[7, 8]. In this study, the C7 and S1 vertebrae were used as reference points. As mentioned above, our team previously conducted a study assessing reliability of postural indices in scoliosis, including trunk list, using digital photographs. We found high test-retest reliability (dependability coefficient of 0.98, and standard error of measurement (SEM) of 2.9 mm[16]. Engsberg and colleagues[13] put skin surface markers on the spinous processes of individuals with spinal deformity and then took radiographs. He measured trunk list on the radiographs from the skin surface markers that had been placed at the spinous processes and then directly from the spinous processes. He reported a strong correlation (r = 0.80) between these two measurements[13]. However, Lenke et al.'s results contradict those of Engsberg. He assessed trunk list in thirty individuals with IS during upright posture and during gait using videographic gait analysis and via radiographs and he found only weak correlations between all three measurements[11]. These differences may be attributed to landmark placement (spinous process vs. central of vertebral body) and position during evaluation.

2.1.3 Trunk List and its Associations

Trunk list is an important measurement since it may be a manifestation of scoliosis and pain and also have an effect on self-image and mental health. It has even been suggested to lead to scoliotic curvatures of the spine. In the next sections these potential associations are discussed.

Trunk list is an important measurement, performed by physicians and physical therapists. It has been associated with back pain and intervertebral disc lesions[18]. Reducing trunk list using reverse trunk list exercises and reverse trunk list traction (i.e. the Harrison treatment method), also decreases pain in persons with low back pain[1]. A retrospective study of 2442 children and adolescents with IS examined various aspects potentially related to pain experienced. Trunk list greater than 1 cm was seen in 220 children; in 11% of those presenting with pain (62/560) and in 8% of those not presenting with pain (158/1882), p=0.052. The authors do not mention if there was a difference in pain intensity, duration or frequency in those with trunk list versus those with no trunk list. In addition, in their analysis of pain and trunk list, the authors do not include 210 individuals who presented with pain after their initial diagnosis of IS[19]. In a study of 34 patients presenting with lumbar disc herniation, the investigators found that those with trunk list (n=10) had significantly increased nerve root pressure than those without trunk list (82.1 mmHg versus 41.2 mmHg, $p<0.05$). They do not explain the phenomenon, rather express that further research is warranted[20]. Souchard believes that trunk list develops as an antalgic posture secondary to pain experienced by individuals[6]. Therefore, addressing trunk list may also address an individual's pain and the reverse can be presumed as well, which has ramifications on health related quality of life.

Trunk list may be correlated with type of scoliosis. Gauchard et al.[21] found that trunk list, measured using the plumbline was most common in those with lumbar scoliosis, followed by thoracolumbar scoliosis, then by thoracic scoliosis and finally by double major curves. Gram and Hasan[22] reported trunk list, measured using infrared-emitting markers, to be more common in those with thoracic scoliosis than lumbar scoliosis in both standing and sitting positions.

Another study demonstrated that in 298 adults with scoliosis (with a Cobb angle > 30°), persons who had a trunk list > 4cm as measured on radiographs and who had not been operated on had poorer functional level (Oswestry Disability Index; SF-12) and increased pain (SRS-29) compared with the those who had trunk list of < 4cm[23]. Based on clinical experience, Floman expressed his opinion that trunk list may also be associated with development of pelvic obliquity, scoliotic curve progression following skeletal maturity and back pain[4], but this has never been proven. Trunk list has also been suggested to lead to scoliotic curve formation secondary to increased loads, vertebral growth alteration and postural changes[24]. Absence of trunk list is also thought to be associated with improved scoliotic prognosis[25]. Authors have demonstrated that when healthy individuals assume a trunk list, a correlation exists between the degree of the trunk list and Cobb angle, as well as the Risser-Ferguson and lumbosacral angles[26]. However, these results have not been duplicated in persons with IS. If these correlations do exist in individuals with scoliosis, then perhaps trunk list could serve as an indicator of both progression and severity of scoliosis. Further, treatment of trunk list could then potentially help improve an individual's scoliotic curve.

2.2 Adolescent Idiopathic Scoliosis

In the following section, Adolescent Idiopathic Scoliosis is dicussed; namely its classification, symptoms, prognosis, evaluation and treatment. As this study deals with scoliosis of an idiopathic nature, the discussion focuses on IS.

2.2.1 Introduction

Adolescent Idiopathic Scoliosis (AIS) is a three-dimensional deformity of the spine, characterized by a lateral deviation and axial rotation of the spine. Studies estimate that 1-3% of children aged 10-16 years are at risk of developing a scoliotic curve with a Cobb angle greater than 10°[27-29]. Idiopathic scoliosis is more common in females; with a ratio of 5.4:1 for curves greater than 20 degrees and a ratio of 7:1 for curves under treatment[30].

The etiology of IS is unknown, yet several hypotheses and associations do exist. Individuals with scoliosis have a family history of the condition approximately 30% of the time, however this does not appear to be predictive of curve progression or severity[25]. Other potential hypotheses involve hormonal imbalance, muscle and tissue imbalance (including trunk list), neurological abnormalities and associations to puberty[24, 27].

Clinical appearance of scoliosis may include one scapula that protrudes more than the other, inequality in shoulder and pelvis levels, asymmetric appearance of breasts and prominence on one side of the back[31]. The waist angles are uneven; being larger on the side of the concavity and smaller on the side of the convexity[7]. The arm on the side of the concavity may hang closer to the body than the other arm[7]. Asymmetry of the paraspinal muscles leads to bulging and weakening on the convex side and a flattening and shortening of the muscles on the concave side[7, 32]. Individuals may lack normal flexibility and may have asymmetric side bending. On the convex side of the curve, the rotation can lead to a rib hump (or gibbosity), which is always apparent in a forward bent position and may be seen in standing[32]. A functional leg length discrepancy (i.e. true leg lengths are equal but they appear not to be) may also be present[7].

2.2.2 Classification and types of scoliosis

Scoliosis is classified first by cause – namely idiopathic (of unknown cause), osteopathic (due to spinal disease or bony anomaly), myopathic (due to muscle weakness) or associated with neurological conditions. Idiopathic scoliosis accounts for 80% of scoliotic curves. It is further classified by age of appearance; namely infantile (under 3 years of age), juvenile (4 to puberty), adolescent (puberty years) or adult (mature skeleton)[32].

Scoliosis can also be categorized as structural or functional. Functional scoliosis is caused by factors such as pain, poor posture, leg length discrepancy, spondylolisthesis or herniated disc causing muscle spasm; i.e. factors in which the vertebrae are not involved. A functional scoliosis will disappear if the causative factor is addressed. When a fixed curvature of the spine exists, the scoliosis is designated as structural; generally including vertebral rotation and translation, as well as asymmetry of the surrounding soft tissue structures[32].

Types of scoliosis are commonly classified by curve pattern designated according to the level of the apex of the curve and the direction. For example, a right thoracic curve has a thoracic apex with a right convexity. A cervical scoliosis' apex is between the vertebrae C1-C6. A cervico-thoracic curve's apex is at the C7 or T1 vertebrae. A thoracic scoliosis apex ranges between the T2 and T11 vertebrae. A thoraco-lumbar curve's apex is either at the T12 or L1 vertebrae. A lumbar scoliosis apex is between the L2 and L4 vertebrae. A lumbo-sacral scoliosis' apex is at the L5 or S1 vertebrae[7].

A scoliotic curve can also be classified as single or double major according to the number of curvatures in the spine. One author states that curve types include: double major curves (37%), thoracic curves (22.1%), lumbar curves (23.6%), thoracolumbar curves (16%) or cervicothoracic curves (1.3%) [33]. Another author found that curve types include: main thoracic (51%), double thoracic (20%), double major (11%), triple major (3%), thoracolumbar/lumbar (12%) and thoracolumbar/lumbar-main thoracic (where the thoracolumbar/lumbar curve is the major curve) (3%)[34].

2.2.3 Scoliosis Symptoms

Individuals with scoliosis can have symptoms such as pain, poor self-image and mental health, and impaired pulmonary function, which can hinder quality of life. These are discussed below.

2.2.3.1 Pain

Between 23-73 % of individuals with IS present with back pain[19, 31, 35-37]. This large range in prevalence of pain in those with IS could be due to confounding factors such as age, weight, other comorbidities and activity level[37]. In addition, while some looked at present pain, others examined pain within the past year. Ramirez et al.[19] performed a retrospective study of 2442 patients with IS, where they investigated the prevalence of back pain. They found an association between back pain and age > 15 years, skeletal maturity, post-menarchal status and a history of injury. 9% of those with pain had an underlying pathological condition, including spondylosis and Scheurmann kyphosis[19]. Another study by Ramirez et al.[38] investigated back pain in 303 individuals with IS wearing back braces. He found that of those with back pain, 26% eventually required spinal fusion surgery because of curve progression, while only 2.6% of the group without pain required fusion. Thus, back pain appears to be associated with curve progression[38]. Individuals with IS have increased pain when compared to controls, however pain does not appear to limit function[39]. Some authors show that there is no correlation between curve magnitude and pain[19, 39, 40], whereas others show that correlation ranging from r=0.32-0.37 exists[41-43].

2.2.3.2 Mental Health, Self-Image and Health Related Quality of Life in Persons with IS

Adolescents with IS are more likely to exhibit poor mental health[35, 42, 44] and self-image[42, 45, 46], which both correlate with Cobb angle (r = -0.27 and -0.50 respectively)[42]. Payne et al.[44] studied 34706 adolescents, 685 of whom had IS, and found that scoliosis is an independent risk factor for suicidal thought, worry and concern over body development. Ascani et al.[35] studied individuals with untreated IS after skeletal maturity and found that 19% of his cohort had real psychological disturbances; the majority were female, had thoracic curves and Cobb angles>40°[35]. In a long term follow-up study of 2092 adults with AIS, individuals with scoliosis perceived themselves to be less healthy and had poorer body image, however they had improved perception of self as compared to controls[46]. A review investigating psychosocial issues and quality of life in scoliosis concluded that compared to healthy controls, adolescents with IS have poorer health-related quality of life, body image and psychosocial functioning[45].

2.2.3.3 Pulmonary function

Pulmonary function is highly associated with curve size. It is affected as well by number of vertebrae involved, degree of rotation, location of uppermost vertebrae and patient's age[47]. Reduced vital capacity, frequent shortness of breath and less commonly cardiopulmonary compromise, have been associated with curves greater than 50°[27]. Early onset idiopathic scoliosis patients can present with substantial loss of both vital capacity and forced expiratory volume, which can cause pulmonary hypertension, right heart failure and even death. However, this is quite rarely seen in AIS[27].

2.2.4 Prognostic Factors

Scoliosis prognosis varies according to many factors; including age, physical maturity level, sex, curve size and curve pattern. Clinicians use these factors to decide on treatment plans for their patients. In this section, these factors are discussed.

Various factors are predictive of scoliosis progression in individuals with AIS, such as: time of diagnosis compared with puberty, sex, curve severity, curve pattern, degree of vertebral rotation, as well as other factors, whose associations have not been definitively proven[25, 27].

Curve progression often occurs during periods of growth or puberty. If an adolescent or child diagnosed with AIS is at the beginning of the puberty process, his/her curve must be monitored very closely as this is the time of greatest risk for curve progression. The occurrence of menarche, the Risser sign (iliac crest progressive ossification) and the individual's age are all evaluated when determining progression risk[25]. Following menarche and passing a Risser Stage II (iliac apophyses 50% ossified) are both factors that reduce risk of scoliosis progression to less than 20%[16 25, 48]. A modification to the Risser sign has been proposed that signals the start of rapid growth[49].

In patients who are physiologically immature, Cobb angles of 30° or more have an increased risk of progression when compared to smaller curves. If a Cobb angle is greater than 50° at skeletal maturity, the curve will likely increase at a rate of 1° per year throughout life[50]. Therefore curve severity is also an important factor in the prediction of prognosis[25].

Curve pattern may also predict progression. Bunnell[25] states that lumbar curves have low risk of progression, thoracolumbar curves have intermediate risk and thoracic curves and double major curves have highest risk of progression. However Bunnell[25] does not report what constitutes high, moderate and low risk. Picault et al.[51] report incidence of progression as 67% for thoracolumbar curves, 62% for double major curves, 58% for thoracic curves and 44% for lumbar curves.

Other factors that are possibly associated with curve progression include the presence of chest deformity, vertebral rotation, trunk list[2, 5, 6] and increase in height of a subject in one year[25, 52]. However, Peterson et al.[52] showed that in individuals with IS an absence of trunk list was significantly associated with curve progression. They hypothesized that individuals with trunk list may sense their imbalance and try to actively correct it.

2.2.5 Scoliotic Measurements and Evaluation

The following sections address measurement of scoliosis and evaluation of patients with IS.

2.2.5.1 Cobb Angle

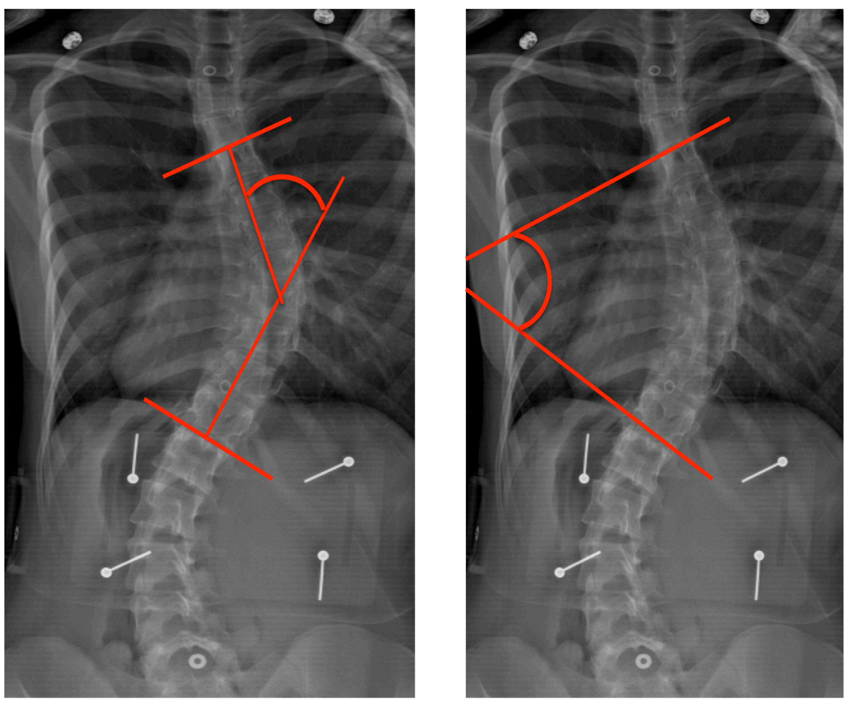
Scoliosis is typically measured and quantified by Cobb Angle. The Cobb angle is the gold standard with regards to monitoring scoliosis progression[53]. It is defined as "the angle between the two straight lines that are tangent to the superior and inferior endplate of the superior and inferior end vertebrae respectively" [54] and it is calculated on radiographs. It is used to quantify a scoliotic curve and the value guides diagnosis, treatment and follow up of these patients. (See figure 2A)

2.2.5.2 Risser-Ferguson angle

A less commonly used measurement is the Risser-Ferguson angle, however certain authors find that this method is a better indicator of scoliosis severity[55, 56]. It is the angle between the two straight lines that connect the centres of the end vertebrae with the centre of the apical vertebrae[54]. (See figure 2B)

Figure 2*: Scoliotic Measurements*

2A: The Cobb angle *2B: The Risser-Fergusson angle*



2.2.5.3 Postural evaluation

Risk of progression of IS increases with postural asymmetries, therefore it is very important to evaluate the posture of individuals with IS[2, 57, 58]. Posture is generally evaluated qualitatively by physicians and physical therapists[13, 59, 60]. Clinicians evaluate symmetry of muscles and bony landmarks, presence of kyphosis or lordosis, trunk list, lower extremity position and symmetry in standing, sitting and lying positions[7].

An evaluation of an individual with scoliosis begins as soon as he/she walks into the office of the clinician. This way, gait can be evaluated without the patient's knowledge and therefore without him/her correcting his/her posture[61].

The individual should be properly undressed and is then observed in the standing position from the front, side and back. From the front, the clinician observes the position of the head relative to the trunk and the position of the trunk relative to the hips. The clinician observes rib cage, shoulder, waist and hip asymmetry, as well as the position of the arms with respect to the trunk (i.e. if they are equidistant)[7]. From the side, the natural curvatures of the spine (thoracic kyphosis and lumbar lordosis) and the presence of anteversion or retroversion of the pelvis are observed[7]. Finally, from the back, the clinician checks alignment of the spine, symmetry of shoulders, scapulae, waist and hips and position of the head. During all this time, clinicians must look for any deformities[61].

The individual's sitting and lying positions should also be observed and the alignment of the spine and symmetry should be rechecked[7]. The clinician should note whether the amount of asymmetry is different in the sitting versus standing positions. Regardless of whether there exists a discrepancy in the symmetry between the lying, sitting and standing positions, leg length discrepancy should be checked[61]. This is typically done using a tape measure to measure the distance from the anterior superior iliac spine to the medial or lateral malleolus[7].

A clinician will ask his/her patient to stand and bend forward in order to see if there is any asymmetry of the ribs, otherwise known as a rib hump. If a hump is present, the clinician uses a tape measure to evaluate the distance between the hump and the hollow[7]. He/she also evaluates the angle of trunk rotation or inclination, which is the angle between the horizontal and the plane across the back at the elevation of a rib/lumbar prominence in forward flexion[62]. The clinician will also evaluate trunk list and sagittal balance, the alignment of the C7 and S1 vertebrae in the sagittal plane, using the plumbline[61].

In standing, the position of an individual's feet can alter his/her posture. For example, standing with one foot forward or with one knee bent can give the impression of a leg length discrepancy. Lenke et al.[11] have mentioned that foot position may influence the correlation between surface marker and radiographic measurement. As such, it is very important to standardize foot position for the evaluation of posture. In addition, when evaluating posture, it is important to avoid postural sway, as it will influence the results of certain measurements. When an individual's feet are close together, he/she has a decreased base of support, therefore decreased balance, leading to increased postural sway[63]. Therefore, foot position is an important component of postural evaluation.

Arm position may also affect posture measurements. Vedantam et al.[64] studied posture evaluation from a lateral view and found that arm position must be standardized. They stated that the ideal arm position for lateral radiographs is arms at the side.

2.2.5.4 Scoliosis Research Society Outcomes Instrument

Besides objective measures of scoliosis and posture, it is important to assess the patient's perspective as well. Patient reported outcomes in scoliosis are measured primarily by the Scoliosis Research Society Outcomes Instrument, which is described below.

2.2.5.4.1 Overview

The Scoliosis Research Society Outcomes Instrument (SRS) was developed as a scoliosis-specific, simple questionnaire for patients with idiopathic scoliosis[65]. It is a patient-based questionnaire, taking into account not only objective measures of an individual's medical condition, but also his/her self-perception of his/her condition. The questionnaire has evolved and now includes 22 questions (SRS-22) covering the following five domains: pain, function, self-perceived image, mental health and satisfaction with management. Each domain (except satisfaction with management) has 5 corresponding questions that address various aspects of the domain. For example, pain is addressed with five questions regarding intensity, frequency, medication etc. For each domain, a score out of five is obtained; 5 being highest and 0 being lowest health related quality of life. The SRS-22 has been modified into many languages, including a cross-cultural French Canadian adaptation[66]. The SRS-22 French Canadian version (SRS-22vf) will be discussed in more depth, as it is what was used for our study.

2.2.5.4.2 Psychometric Properties

Beausejour et al.[66] performed a cross-cultural French Canadian translation of the SRS-22. They demonstrated that the SRS-22vf had very good overall reliability (Cronbach $\alpha = 0.86$). In addition, they compared the SRS-22vf to the SF-12, showing a concurrent validity of 0.79 for the total scores. Moderate ceiling effects were observed in the pain and satisfaction with management domains. The psychometric properties observed in the SRS-22vf are consistent with those in the original version.

2.2.6 Treatment

As mentioned in Section 2.2.4, postural asymmetry can lead to progression of scoliosis. This implies that the treatment of postural asymmetries is important in scoliosis. In the next sections, possible treatments of scoliosis, including medical, surgical and physiotherapy treatments will be explored.

2.2.6.1 Indications for treatment

Scoliosis treatment varies according to the size of the scoliotic curve, as well as the amount of growth remaining[27]. However, other factors, including pain and neurological changes will also guide the treatment approach[32].

Generally, if a Cobb angle is less than 25°, physicians will monitor the scoliosis every 6 to months looking for a progression of the curve or of symptoms[32]. If the curve begins to progress, physicians may opt for the following treatment options: physiotherapy, bracing or surgery.

With a Cobb angle ranging between 20° and 45°, physicians will generally recommend physiotherapy. For a Cobb angle that is greater than 25°, bracing is recommended in order to prevent curve progression until reaching skeletal maturity (defined as Risser 3 or 4 – iliac crests ossification of 75% and 100% respectively[67]), at which point the risk of curve progression diminishes greatly. For a Cobb angle that is greater than 45˚ or in the presence of chronic pain or neurological changes secondary to the curvature, physicians usually opt for corrective surgery[32].

2.2.6.2 Physiotherapy

Physiotherapy focuses on preventing the progression of IS, enhancing the effect of a brace if the individual has one, improving neuromuscular control and stability of the spine, decreasing biomechanical postural collapse and improving breathing function[27, 68]. Physiotherapy goals include correcting muscle imbalance, coordination, spinal proprioception and decreasing pain[27]. Different physiotherapeutic methods to treat scoliosis exist, which include side shift exercises[69], the Schroth method[70], the Scientific Exercises Approach to Scoliosis (SEAS) method[71], the Dobosiewicz method[72] and Global Postural Reeducation[6]. Side shift exercises are an active form of auto-correction where the patient is taught to shift the trunk sideways over the pelvis in the direction opposite to the curve convexity[69]. The Schroth method corrects scoliotic postures and breathing patterns with the help of propioceptive and exteroceptive stimulation and mirror control[70]. SEAS is a program of individually adapted exercises based on active self-corrective movements performed to achieve maximum correction[71]. The Dobosiewicz method is a method that utilizes active three-dimensional auto-correcting concerning the primary curvature and mobilizations towards correction of the curvature[72]. Finally, global postural reeducation is a combination of overall stretching positions, which gradually evolve from an initial position of minimal tension to a final position with an overall stretch, with the intention of stretching tissues and decreasing tensions[6].

There exists much debate with regards to physical exercise in the treatment of AIS. Two studies concluded that a regime of physical exercise does not improve or halt the progression of scoliosis[10, 73]. However, the first study did not specify the type of exercise regime[10]. In the second study, physiotherapists administered home exercise programs to individuals with IS with Cobb angles ranging between 4°-22° and compliance was only 50%[73]. A third study indicated that adding a physical exercise regime to bracing had no additional benefits with regards to reducing or maintaining Cobb angles, however these were aerobic exercises whose goal was not to decrease spinal curvatures but rather to improve exercise capacity[74]. On the other hand, more recent studies have shown positive results. Den Boer[69] compared a group receiving side shift physiotherapeutic exercises to another who were given corrective braces and found similar results in both groups: reduced curve progression and even some improvement in the scoliosis. Weiss et al.[75] performed a prospective follow-up study, comparing a group that had not received treatment with a group that had received the Schroth method as therapy and found that progression was 1.5 to 2.9 times higher in the non-treatment group ($p<0.01$), implying that the Schroth method may decrease progression of IS. A prospective cohort study regarding the efficacy of SEAS versus traditional physiotherapy demonstrated that among those receiving SEAS 11.5% required bracing secondary to progression versus 30.8% in the traditional treatment group[71]. Negrini et al.[68] reviewed the available literature on the subject of therapeutic exercise in IS and concluded that those who received physiotherapy (versus those who did not) tended to either maintain or reduce the degree of spinal curvature irrespective of the amount of baseline curvature. Physiotherapy improves breathing function[74, 76], strength[77] and postural balance[78] in patients with IS.

Although there is still controversy regarding the efficacy of therapeutic exercise in AIS, the recent studies described above support its use. Well-designed randomized controlled trials are needed to establish whether exercise improves or halts progression of scoliosis.

2.2.6.3 Bracing

Braces are typically used for Cobb angles greater than 25°[32]. According to Willers et al.[79], the prevention of curve progression is achieved in 85% to 88% of cases. Many different orthoses have been developed to treat scoliosis. The effectiveness of the bracing seems to be affected by the brace used. Boston braces are effective in preventing progression but do not decrease Cobb angles[80, 81]. A retrospective study showed that the use of Milwaukee brace did not decrease the need for surgical intervention[82]. However Carr and associates[83], who examined the results of treatment with a Milwaukee brace (without a control group) are of the opinion that the Milwaulkee brace is the most successful in halting progression of scoliosis. Some suggest that the Cheneau brace, used frequently in Europe, may correct a Cobb angle more than 40% from the initial Cobb angle[84, 85]. Different brace wearing protocols exist – some requiring subjects to wear the brace for 23 hours/day, others only in the evening, however some studies found that exclusive night-time wear is not effective[86, 87]. An important aspect of bracing is compliance. Positive associations between compliance in wearing the brace and scoliosis outcome have been demonstrated[80, 88, 89]. In the most recent study, 34 individuals with IS brace-wearing habits were monitored using a temperature sensor and logger that was embedded in the brace. The 15 patients whose curves progressed more than 5° had compliance rates of 62% versus a rate of 85% in the curves that did not progress ($p = 0.004$)[88].

2.2.6.4 Surgical Intervention

The objectives of surgery are to stop the progression, achieve correction of the scoliosis in 3 planes, to balance the trunk, to minimize complications[27] and to improve quality of life[90]. The most common surgical procedure is fusion with posterior segmental instrumentation[32]. Danielsonn[90] reviewed evidence of whether correcting spinal deformity impacts quality of life of individuals with AIS. He found 3 articles[91-93] stating that there was a significant improvement in quality of life after spinal fusion as compared to before surgery. Another review study found that in several long-term follow-up studies, a decreased spinal curvature was maintained for 10-20 years[94].

Summary

Trunk list is a trait commonly seen in individuals with AIS. It may be associated with scoliotic curve development and progression, back pain and development of pelvic obliquity[4, 24, 25], although there are no studies to date that support these theories. However, before examining associations and correlations between trunk list and other factors, the methods used to evaluate trunk list must be shown to be reliable and valid. In this study, we try to fill this gap in knowledge: i.e. assess the psychometric properties of the clinical trunk list measure with the plumbline.

Chapter 3: Objectives and Hypothesis

3.1 Objectives

The general objective of this study is to evaluate trunk list from C7 – S1 in persons with idiopathic scoliosis, using a plumbline.

The specific objectives are:

1) To determine the inter-trial, test-retest reliability and the standard error of measurement of the plumbline and the photographic methods to measure trunk list with feet together and feet apart
2) to verify the validity of this measure compared to radiographs (gold standard)
3) to explore the association between trunk list and other factors including Cobb angle, type of scoliosis, pain, mental health and self-image.

3.2 Hypothesis

The hypotheses of this research study were :

1) The degree of inter-trial and test-retest reliability will be good for the measure of trunk list using a plumbline (≥ 0.75). The measure of trunk list taken with the plumbline will be comparable to the measurement taken using a photograph (≥ 0.75).
2) The validity of this measurement will be good when compared with x-rays (≥ 0.75).
3) Trunk list will be correlated with Cobb angle, pain and self-image. Trunk list will be correlated with single curvatures more than double major curves.

Chapter 4: Methods

The following section describes the methods used for this study. First, the process of obtaining approval from the ethics committee is described. Then, the process of participant recruitment, inclusion and exclusion criteria, materials required and the procedure used to measure trunk list using the plumbine, via photographs and on radiographs are described. Finally, the methods of acquisition of clinical information, statistical analysis and the justification of the sample size are defined.

4.1 Ethics Approval

Ethics approval was obtained from the Centre de Recherche du CHU Sainte-Justine (Appendix A) and all subjects and the parents of those under the age of 18 years signed an informed consent form prior to participating in the study (Appendix B).

4.2 Participant Recruitment

Potential participants were recruited during scoliosis clinics at Centre Hospitalier Universitaire Sainte-Justine in Montreal.

4.2.1 Inclusion and Exclusion Criteria

The following lists the inclusion and exclusion criteria used while recruiting individuals for this study.

Inclusion Criteria:

- Youth aged between 10 and 21 years inclusively
- Diagnosis of Idiopathic Scoliosis
- Participants with X-rays taken on the same day

Exclusion criteria:

- Participants who have had back surgery
- Participants who present with a leg length discrepancy > 1.5cm

4.3 Materials

4.3.1 Plumbline, ruler and stickers

A plumbline (string attached to a weight) was required, in addition to a ruler to measure the horizontal distance between the C7 and S1 vertebrae. Two 5 mm round stickers were used as markers on each participant to mark the bony landmarks of C7 and S1 vertebrae.

4.3.2 Digital Camera

A digital camera was required for comparative purposes between the measurement of trunk list by photographs and the manual measure. A Lumix Panasonic camera, model number FX01, was used in this study.

4.3.3 Radiographs

Radiographs taken as part of the orthopaedic evaluation were retrieved and served as the gold standard of comparison. No new x-rays were ordered for this study.

4.3.4 Two position bases for the feet

To assure reproducibility of the findings, position bases were drawn on the floor to indicate where the subject should stand. Two position bases were used. Position 1 was with heels together and feet opened in a «V» with an angle of 30º. According to some authors[6, 95], this is the foot position of reference for the evaluation of posture. Position 2 (see figure 3) was with feet apart on the same position base that is used for radiographs.

Figure 3: Position 2 – Feet apart on position base

4.3.5 Questionnaires

Participants responded to a health status questionnaire developed by our team (see Appendix C) as well as a validated questionnaire for adolescents with scoliosis, the french version of the SRS-22 (see Appendix D). The health status questionnaire addresses past medical history, associated conditions, pain, self-perception of posture and treatment.

To evaluate quality of life, including pain, self-image and mental health, we used the French version of the Scoliosis Research Society Questionnaire-22. It is described in depth in the literature review (chapter 2, section 2.2.5.4).

4.4 Procedure

The following section describes how the data was collected using the plumbline method, via digital photography and from radiographs.

4.4.1 Measurement of Trunk list on Participants

One physiotherapist was responsible for conducting all the measurements in a private room, adjacent to the clinic area. Each of the study participants was measured as follows. The physiotherapist marked the bony landmarks of C7 and S1 with the stickers. The participant was asked to stand on a base, positioned feet in a « V » with an angle of 30º between the feet (position 1). During the acquisition, the participant was asked to look straight ahead, to not move and to breathe normally. The trunk list measurement was completed as follows. A plumbline was suspended from C7 and I measured the horizontal distance between the plumbline and S1. The trunk list was measured in centimetres with a ruler and then converted to millimetres. Subsequent to the plumbline measurement, photos were taken from a posterior view. The same procedure was done in position 2 (feet apart: same position plate used for radiographs). The participant was asked to move from the position and then asked again to stand in position 1 and subsequently in position 2, at which times the trunk list measurement and photographs were taken again. The stickers were then removed from the subject. After an hour delay, during which the participant filled out the SRS-22vf questionnaire (see Chapter 2, Section 2.2.5.4), the participant was repositioned and the measurement was taken again in the two different positions and techniques. The stickers were then removed.

4.4.2 Measurement of Trunk list on Radiographs

A technician performed the trunk list measurements on the radiographs. He marked the C7 and S1 vertebrae and projected a vertical line down from C7. The horizontal distance between C7 and S1 is directly displayed on the digital radiographs.

4.4.3 Measurement of Trunk list on photographs

The trunk list measurements on the photographs were performed by a physiotherapist using a software program. This program was developed in a previous study at CHU Ste-Justine[16]. The software uses interactive click-on markers with the computer mouse. The physiotherapist selected the C7 and S1 vertebrae from the graphic interface and placed them directly on the corresponding marked anatomical landmarks. The software automatically calculated and displayed the distance. The physiotherapist was blinded with respect to the photographs: i.e. she did not know which participant's photograph she was measuring.

4.5 Statistical Analysis

In this section, the statistical analyses for each of the three objectives of this study are described.

4.5.1 Objective 1

For objective 1, which was to determine the inter-trial, test-retest reliability and the standard error of measurement of the plumbline and the photographic methods to measure trunk list in both foot positions, the generalizability theory was used

The generalizability theory is an extension of the intraclass correlation coefficient used in classical theory[96]. The generalizability analysis quantifies different sources of error or variance (such as person, occasion, trial etc) rather than designating all variance simply as error. This theory enables researchers to quantify various sources of error and then to determine ways to eliminate them, ultimately allowing for better measurement techniques[97, 98].

There are two components when using generalizability theory; first the generalizability study (G study) and then the decision study (D study). The G study allows for the determination of variances attributed to different factors or sources of error[96], taking into account systematic and unsystematic error sources. Random or unsystematic variance stems from error associated with interactions between factors, while systematic variance stems from the factors themselves. The expected source of variance is that attributed to person, since each person evaluated is expected to be different. Other sources of variance include factors related to the particular study, their interactions and the residual random error, being the unexplained error or error caused by interaction between all the factors. In our study, the factors used were person (P), trial (T) and session (S). The difference between occasion and trial is that the stickers are removed between occasions, whereas they are not between trials. Thus, in this study, seven sources of error variance, P, S, T, PT, TS, PS and PTS, can be identified. The sources of error considered in this study are as follows:

σ_p^2 = inter person variance

σ_t^2 = inter trial variance (systematic variance)

σ_s^2 = inter session variance (systematic variance)

σ_{ps}^2 = variance associated with interactions between person and session (random variance)

σ_{ts}^2 = variance associated with interactions between trial and session (random variance)

σ_{pt}^2 = variance associated with interactions between person and trial (random variance)

σ_{pts}^2 = variance associated with interactions between person, trial and session (residual random variance)

The D study determines the reliability of a particular protocol using the results obtained in the G study [96]. From this, we are able to design a measurement procedure that minimizes error.

The G- and D-studies allow dependability coefficients (ϕ) and generalizability coefficients (ρ^2) to be calculated. The dependability coefficient, a measure of reliability in the generalizability study, is the ratio between the inter-person variance (σ^2_p) and the sum of the inter-person variance and all possible sources of error, i.e. the sum of both systematic and random error variances which is called absolute error variances (σ^2_{abs})[97]. Like the intra-class coefficient (ICC), the dependability coefficient ranges between 0 and 1: 0 is null reliability and 1, perfect reliability. Portney and Watkins[99] have suggested that values above 0.75 can be considered as good reliability, those between 0.50 and 0.75 as moderate and those under 0.5 as poor.

The generalizability coefficient (ρ^2) is the ratio of the inter-subject variance versus the sum of the inter-subject variance and the relative error variance (only including sources of error where there is interaction with subjects). The generalizability coefficient still takes into account the number of trials and sessions; therefore it can be tailored to any particular protocol. Since the generalizability coefficient only takes into account error where there is interaction with the subject, ρ^2 is greater than φ. However the generalizability coefficient still ranges from zero to one; one being perfect reliability.

To appreciate the errors in terms of the unit of measurement, the standard error of measurement (SEM), which is the root square of the absolute error variance, was computed [97]. We used the GENOVA program for the generalizability analysis[100].

4.5.2 Objective 2

For objective 2, which was to verify the validity of this measure compared to radiographs (gold standard), the Pearson correlation coefficient was used to compare distances measured by the plumbline method and those measures on radiographs. The Bland and Altman method also served to document the agreement between the two clinical measurements of trunk list and the radiograph measurement. For this analysis, we used the first trial of each session.

4.5.2.1 Pearson Correlation Coefficient

The Pearson Correlation Coefficient (r) is a measurement of the relationship between two variables. It ranges from -1 to +1; +1 being a perfect positive relationship, -1 being a perfect negative relationship and 0 being no relationship. The closer the value is to -/+1, the stronger the relationship is. Our study will use the following to define the strength of correlations found: <0.25 as little or no relationship; 0.25 to 0.50 as fair; 0.50 to 0.75 as moderate to good; and >0.75 as good to excellent (for absolute values of the aforementioned numbers)[101].

4.5.2.2 Bland and Altman

In the process of validating clinical tools, one compares with the gold standard. Although Pearson correlation is the most widely used and accepted method to evaluate validity, it does not show the agreement. For example, a perfect correlation can exist even when the two compared items are not in the same units or in the case where one method is consistently under/overestimating the true value. The Bland and Altman method alleviates this problem by directly comparing the values obtained using the two methods, however the two methods must be measured using the same units of measurement. It plots the mean of the two measurements versus the difference. The mean difference is calculated, as are the maximum and minimum difference values (called limits of agreement); the closer all these values are to zero, the closer the sample comes to perfect agreement. Studies rarely show perfect agreement between two measures and therefore an accepted difference, based on the construct being evaluated, should be set prior to performing the analysis[102].

4.5.3 Objective 3

For objective 3, which was to explore the association between trunk list and each of the following: Cobb angle, type of scoliosis, pain, mental health and self-image; the Pearson correlation coefficient was calculated between trunk list (plumbline measure) and Cobb angle, pain, mental health and self-image. Chi-square and analysis of variance (ANOVA) were calculated between trunk list and type of scoliosis (comparing single versus double curvatures). Means of double versus single curvatures were also compared using the unpaired samples t-test.

Multiple linear regression models were constructed to explore various associations. These were: 1) trunk list as a function of Cobb angle, pain and scoliosis type; 2) pain as a function of mental health, Cobb angle and trunk list; 3) self-image as a function of trunk list, Cobb angle and mental health; and 4) mental health as a function of pain, trunk list and self-image. Type of scoliosis was designated as single versus double for the purposes of the regression models.

4.6 Sample Size Justification

Sample size was calculated based on objective 2: validation of the trunk list measure with measurement on radiographs as the gold standard. If the correlation between these two measures is assumed to be high, i.e. in the area of 0.9 and we are willing to accept an absolute error of 0.3 and an alpha level of 0.05, then 55 subjects would be required.

Chapter 5 : Article 1

Title: Reliability and Validity of the Clinical Measurement of Trunk List in Children and Adolescents with Idiopathic Scoliosis

Objectives : The objectives of this study were to evaluate reliability and validity of the plumbline to measure trunk list in persons with idiopathic scoliosis. Secondary objectives include evaluating effects of foot position on trunk list measurement and evaluating reliability and validity of the trunk list measurement obtained from photographs.

To be submitted to “Physical Therapy” in July 2011.

Title Page

Title: Reliability and Validity of the Clinical Measurement of Trunk List in Children and Adolescents with Idiopathic Scoliosis

Authors:
Erin Grunstein, BSc PT [1]
Carole Fortin, PT PhD [1,2]
Stefan Parent, MD PhD [1,2]
Michelle Houde BSc[3]
Hubert Labelle, MD [1,2]
Debbie Feldman, PT PhD [1,3]

1. University of Montreal
2. Sainte Justine Hospital
3. Direction de santé publique de Montréal

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Abstract

Study Design: Reliability and validity studies.

Objectives: To evaluate reliability and validity of the plumbline to measure trunk list in persons with idiopathic scoliosis. Secondary objectives include evaluating effects of foot position on trunk list measurement and evaluating reliability and validity of the trunk list measurement obtained from photographs.

Summary of background data: Measurement of trunk list is an important component of posture evaluation. The plumbline is commonly used to evaluate trunk list in a clinical setting. However, information on reliability and validity is lacking.

Methods: Trunk list was measured on 55 participants with idiopathic scoliosis with plumbline and photographic methods on two occasions by the same evaluator. At each occasion: two measurements were taken with feet together (FT) and two with feet apart (FA). Trunk list was calculated on radiographs taken that day. Generalizability theory was used to estimate the reliability and standard error of measurement (SEM) for the overall, test-retest and inter-trials designs. Pearson correlation coefficients (r) was used to assess validity of trunk list compared with the radiographic method.

Results: Plumbline measurement demonstrated high test-retest reliability (FT: ϕ=0.98 and SEM=2.0 to 2.2 mm ; FA: ϕ=0.98, SEM=2.0mm) and high inter-trial reliability (FT: ϕ=0.99, SEM=1.2mm ; FA: ϕ=0.99, SEM=1.2mm). The test-retest and inter-trial reliability of the photographic method was slightly lower for the two foot positions (ϕ = 0.90-0.98; SEM: 2.7 to 5.8mm).The plumbline and photographic methods had good correlation with the measure obtained via radiograph (plumbline: r=0.79-0.83; photograph: r=0.75-0.78) in both foot positions.

Conclusions: The measurement of trunk list using the plumbline or via photograph is both reliable and valid for both foot positions.

Keywords: trunk list, plumbline, scoliosis, lateral trunk shift

Mini Abstract

Trunk list is commonly seen in individuals with scoliosis and is evaluated using a plumbline, yet little information exists regarding its psychometric properties. Photographs can also be used to evaluate trunk list. Our research demonstrates that the plumbline and photographic measurements are valid and reliable methods to evaluate trunk list.

Key Points

1. Trunk list is often present in individuals with idiopathic scoliosis, yet little research exists regarding its measurement and psychometric properties.
2. The plumbline is a valid and reliable tool to measure trunk list with feet together or apart in individuals with idiopathic scoliosis.
3. Photographic measurement is also a valid and reliable method to measure trunk list with feet together or apart in individuals with idiopathic scoliosis.

INTRODUCTION

Trunk list, or lateral translation of the spine, is an important clinical sign in patients with scoliosis and low back pain[2, 8, 10, 103]. It may also be associated with pain, development of pelvic obliquity and curve progression in patients with IS[3, 4], although, this has not been proven. Thus, there is a need for further study regarding trunk list and associated impairments. In order to do so, it is crucial to ensure that trunk list is measured appropriately and accurately. Trunk list is typically measured clinically using a plumbline and determining the horizontal displacement from midline.

There are only a few studies that address trunk list. McLean et al.[8] compared methods: the plumbline, a projected shadow and the 3SPACE Isotrak in the measurement of trunk list and concluded that the optimal method to measure trunk list is with a plumbline. For the plumbline method, trunk list could be measured within 4 mm between two trials. The test-retest and inter-rater coefficients of repeatability were 5 to 8 mm and 10 mm, respectively. However, these measures of reliability were done among persons who did not actually have trunk list, rather trunk list was simulated by laterally displacing a mark on T12. Furthermore, this study evaluated trunk list between T12 and S1, whereas, in persons with IS, this should be measured between C7 or T1 and S1, because the deviation is commonly present in the thoracic spine.

Our team previously conducted a study assessing reliability of posture indices in IS, including trunk list, using digital photographs. We found high test-retest reliability for trunk list measurement (dependability coefficient of 0.98, and standard error of measurement (SEM) of 2.9 mm)[15]. However, it remains important to establish whether clinical measurement of trunk list (photographs or plumbline method) correlate with measurements taken via radiographs. Lenke et al.[11] showed only weak correlations between measurements of trunk list taken from bony landmarks on radiographs and skin surface markers when measurements were taken at different times and positions. Engsberg et al.[13] demonstrated strong correlations ($r = 0.89$) when this measurement was taken simultaneously on radiographs. However, both measurements (surface markers and bony landmarks) were calculated from radiographs. More recently, Fortin et al.[16] found good concurrent validity for trunk list measurement from digital photographs with radiograph measurements among persons with IS ($r=0.76$). Although these studies indicate some degree of reliability and validity for the clinical measurement of trunk list, none of these studies specifically used a plumbline. Therefore there is a need to document the reliability and validity of the use of the plumbline method to measure trunk list to ascertain its relevance in a clinical setting.

Objectives

The general objective of this study was to evaluate the reliability and validity of the plumbline method to measure trunk list from C7 – S1 in persons with IS.

Specific objectives were 1) to determine the inter-trial and test-retest reliability and the standard error of measurement (SEM) of this method in two different foot positions (feet together – FT and feet apart – FA); 2) to verify the concurrent validity of this measure with radiographs (gold standard) for the two foot positions and 3) to compare the reliability and validity of the plumbline method with trunk list measurements from photographs.

MATERIALS AND METHODS

Participants

Fifty-five (55) participants (47 female, 8 male), aged 10 to 19 years presenting with IS (Cobb angle between 10° and 60°) and who had radiographs taken the same day, were recruited from a scoliosis clinic at a tertiary care pediatric hospital. Mean age of participants was 14.5 years ±2.2 years and average weight and height 53.4 ± 9.6 Kg and 162.2 ± 9.9 cm, respectively. 27 participants had a thoracic scoliosis (mean of 34º ± 17º), 11 a double major scoliosis (means for each curve of 36º ± 17º; 32º ±15º), 6 a thoraco-lumbar scoliosis (mean of 26º ± 20º) and 11 a lumbar scoliosis (mean of 21º ±12º). We excluded participants who had had a spinal surgery or who had a leg length discrepancy greater than 1.5cm. All participants and their parents signed informed consent forms and the project was approved by the institutional ethics committee.

Procedure

The same physiotherapist was responsible for conducting all measurements. Each of the study participants was measured as follows. The physiotherapist placed stickers on the spinous processes of C7 and S1. The participant was asked to look straight ahead and to stand in a comfortable position on a base that positioned feet in a « V » with an angle of 30º between the feet (denoted as the feet together position or FT). A plumbline was suspended from C7 and the physiotherapist measured the horizontal distance in millimetres between the plumbline and S1 using a rigid ruler. The participant was then asked to move and was subsequently repositioned and the trunk list was re-measured. After each plumbline measurement, digital photographs were taken from a posterior view with a Panasonic Lumix camera (DMC-FX01, 6.3 mega pixels) placed at a distance of 2.5 m and a height of 92 cm. The same procedure was done with feet apart (FA) on the same position plate used for radiograph acquisitions. The stickers were then removed from the participant. After an hour delay, the entire procedure was repeated. The inter-trial reliability differs from the test-retest reliability due to the removing and replacing of stickers; which is not done for the former but is done for the latter.

The physiotherapist performed the trunk list measurements on the photograph using a software program developed in a previous study[16]. The physiotherapist selected the C7 and S1 vertebrae from the graphic interface and placed it directly on the corresponding anatomical landmark. The software program automatically displayed the distance. Trunk list measurement on the radiographs was calculated from the center of the vertebral body of C7 and S1 by a trained technician.

Statistical Analysis

Descriptive statistics (mean, standard deviation (SD)) were used to characterize participants, pain and trunk list measurements from plumbline, photograph and radiograph methods.

Reliability of the trunk list measurement with both plumbline and photograph methods in the two foot positions was assessed according to the generalizability theory, an extension of the intra-class correlation coefficient[97]. The generalizability theory consists of: a) the generalizability study (G-study), and b) a decision study (D-study). The advantage of this approach lies in the determination of potential sources of errors (variances) which can thereafter guide the researchers/clinicians in strategies to be used to reduce these errors[104]. In the present study, the G-study determines the magnitude of the variances attributed to the person, to the systematic errors related to occasion and trial, and to random errors associated with the interactions between occasion and trial, person and occasion, person and trial, as well as the residual error (the interaction between all sources of error and, in this study, corresponds to the person, trial and occasion variance involved). The D-study uses the information of the G-study to determine the reliability of a particular protocol. The dependability coefficients (ϕ) are calculated for a protocol involving one occasion and one trial for three designs: 1) with both factors (trial and occasion) random, 2) with the factor trial fixed giving the test-retest reliability and 3) with the factor occasion fixed giving the inter-trial reliability. Like the intra-class coefficient (ICC), the dependability coefficient ranges between 0 and 1: 0 is null reliability and 1, perfect reliability. Interpretation of the coefficients is as follows: values above 0.75 will be considered as good reliability, those between 0.50 and 0.75 as moderate and those under 0.5 as poor[99]. To appreciate the errors in terms of the unit of measurement, the standard error of measurement (SEM), which is the square root of the absolute error variance, was computed[97]. We used the GENOVA program[100] to perform the generalizability analysis.

For the concurrent validity study, we calculated Pearson correlation coefficients to assess the correlation between trunk list measurement measured by both the plumbline and photographic methods (an average of two trials for each) with measurements on radiographs. Our interpretation of the coefficients was: <0.25 as little or no relationship; 0.25 to 0.50 as fair; 0.50 to 0.75 as moderate to good; and >0.75 as good to excellent excellent[99].

RESULTS

Table 1 describes the means and standard deviations (SD) for trunk list measurement with the plumbline and the photographic methods on two occasions in the two foot positions and for the radiographic method. For the reliability study, two participants' photo analyses were missing and were therefore excluded (n=53).

Reliability

G-Study: Sources of variance

For both plumbline (PL) and photograph (PH) methods with feet together or apart, the inter-person variance was the major source of variance (PL: 97 and 98%; PH: 87 and 88%). The error associated with trial, occasion and the interaction between person-trial and occasion-trial was negligible for both methods in the two feet positions

(0 to 0.3%). The photograph method presents slightly higher error associated with the interaction between person-occasion (PL= 2%; PH= 9%) and residual error (PL= 1%; PH= 4%).

D-Study:

Dependability coefficients show a good level of reliability for the measure of trunk list using the plumbline for feet together and apart in the random, inter-trial and test-retest designs (see Table 2, middle column). The photos also yielded good reliability results (see Table 2, middle column), however the dependability coefficients are lower and SEMs are higher than those obtained using the plumbline method in both foot positions.

Validity

The Pearson correlation coefficients for trunk list measurement for both clinical methods as compared to radiographs were good and statistically significant (see Table 2, third column). The level of validity was slightly higher for the plumbline method. The foot positions did not affect the level of validity.

DISCUSSION

To our knowledge, this study is the first to assess the reliability and validity of trunk list measurement (C7-S1) using the plumbline method among persons with IS. Our results show a good level of reliability and validity for this method, indicating that the plumbline is an appropriate evaluation tool used by clinicians. We found a slightly higher level of reliability with lower SEM values for trunk list measurement using the plumbline method as compared to the photograph method. This minor difference (less than 4mm SEM difference) could be related to the person's oscillations which are well documented in individuals with IS[105, 106]. When taking the measurement manually, the evaluator waits for the person to stop oscillating, however this cannot be done with photography. This finding is corroborated by the error attributable to the interaction between person and occasion, which accounts for 9% of the total variance in the photograph method, yet is negligible in the plumbline method.

Our SEM values for the plumbline method are comparable to those previously reported by McLean et al.[8]. However, for the photograph method, we had lower dependability coefficients (ϕ : 0.87 to 0.91) and higher SEM values (6 to 7 mm) than the ones reported by Fortin and associates[15] (ϕ : 0.95 to 0.98 and SEM: 3 to 4 mm) in the random and test-retest designs. In both our study and Fortin et al.'s, error due to occasion was zero suggesting consistency in marker placement. The difference may be related to the greater variability of trunk list measurement found in Fortin et al.'s study (mean ± SD: 8.4 ± 19.5 mm) which increases the inter-person variance combined with other factors such as greater level of oscillations in this participant group, presence of pain in our cohort or less standardization in the position and information given to the participants. These factors may also explain higher percentage of variance associated with the interaction between person-occasion and the residual error accounting for 13% in our study and which were less than 4% in Fortin et al.'s study. Nevertheless, in the random and test-retest designs, our SEM values for the plumbline method were slightly lower than those reported by Fortin et al. with the photograph method. However, the differences in SEMs between Fortin et al.'s photograph results and the plumbline results of the current study are in the range of 1mm, demonstrating that both methods are appropriate for the clinical assessment of trunk list.

In agreement with previous studies[13, 16], both the plumbline and photographic methods showed good concurrent validity with measurement of trunk list taken on radiographs. The correlation between the clinical and radiographic methods may be affected by the measurement method. In both clinical methods, trunk list was measured from the spinous processes whereas in the radiographic method, trunk list was measured from the center of the vertebral body. Lenke et al.[11] have mentioned that foot position may influence the correlation between surface marker and radiographic measurement. Our results do not support this statement since foot position did not have a significant effect on the reliability and validity of the measurements. We would have expected FA to have higher reliability and validity due to the effect of the larger base of support on one's oscillations and balance[63] and because this foot position was the same as that used for radiographs.

The limitations of this study include not blinding the evaluator and no evaluation of inter-rater reliability. In 2 cases, the radiographs were not performed on the same day. We repeated the analysis with the 2 cases excluded and the results did not change (FA: $r = 0.80$; FT: $r = 0.80$).

CONCLUSION

The results of our study suggest that plumbline is both a valid and reliable method to evaluate trunk list in a clinical setting in individuals with IS. Clinicians can also use photography to evaluate trunk list. Reliability and validity were similar irrespective of foot position. Nevertheless, we recommend that evaluation and re-evaluations of individuals should be done with the feet in a consistent position.

Our team is currently evaluating whether trunk list is associated with other aspects of scoliosis, including Cobb angle, pain, type of scoliosis and self-perception of posture. In future studies, we hope to ascertain whether treating trunk list can assist in the treatment of scoliosis. Other future research avenues include examining the inter-rater reliability as well as doing a longitudinal study to evaluate responsiveness to change and examining trunk list evaluation in other populations.

Table 1: Means and standard deviations (SD) of trunk list measurement for the two occasions with both clinical methods (plumbline and photograph), feet together and feet apart and values of the radiograph measurement

Methods	Occasion 1 Mean (SD)	Occasion 2 Mean (SD)
Plumbline (mm)		
Feet together (FT)	4.49 (15.17)	5.19 (14.90)
Feet apart (FA)	4.85 (15.58)	4.91 (15.22)
Photograph (mm)		
Feet together (FT)	2.51 (18.80)	2.85 (18.52)
Feet apart (FA)	2.51 (18.75)	1.76 (17.99)
Radiograph (mm)	2.60 (23.89)	N/A

Table 2 Reliability: Dependability coefficients (ϕ) and standard error of measurement (SEMs) for the trunk list measurement with plumbline and photograph methods for Random design, Test-retest design (Trial fixed) and Inter-trial design (occasion fixed). Validity: Pearson correlation coefficients for comparison of trunk list measurement between the two clinical methods in the two foot positions and radiograph (x-ray)

Clinical methods	**Reliability**						**Validity**
	Random factors		Test-retest (Trial fixed)		Inter-trial (Occasion fixed)		Correlation coefficients With x-ray (r)*
	ϕ	SEM (mm)	ϕ_O	SEM_O (mm)	ϕ_T	SEM_T (mm)	
Plumbline							
Feet Together	0.97	2.7	0.98	2.2	0.99	1.2	0.83
Feet Apart	0.97	2.5	0.98	2.0	0.99	1.2	0.83
Photos							
Feet Together	0.87	6.6	0.90	5.8	0.98	2.7	0.78
Feet Apart	0.88	6.4	0.91	5.5	0.98	2.7	0.78

*All correlation coefficients were statistically significant $p < 0.005$

Chapter 6 : Article 2

Title : Is Trunk List Associated with Pain, Cobb Angle, Type of Scoliosis, Mental Health and Self-Image in Adolescents with Idiopathic Scoliosis?

Objectives: The objectives of the study were to explore the association between trunk list and the following factors: pain, Cobb angle, type of scoliosis, mental health and self-image, in adolescents with idiopathic scoliosis.

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Title: Is Trunk List Associated with Pain, Cobb Angle, Type of Scoliosis, Mental Health and Self-Image in Adolescents with Idiopathic Scoliosis?

Authors:
Erin Grunstein, BSc PT [1]
Carole Fortin, PT PhD [1,2]
Stefan Parent, MD PhD [1,2]
Michelle Houde BSc[3]
Hubert Labelle, MD [1,2]
Debbie Feldman, PT PhD [1,3]

1. University of Montreal
2. Sainte Justine Hospital
3. Direction de santé publique de Montréal

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Abstract

Study Design: Cross-Sectional Study

Objectives: To explore the association between trunk list and the following factors: pain, Cobb angle, type of scoliosis, mental health and self-image, in adolescents with idiopathic scoliosis.

Summary of background data: Trunk list is often found in persons with scoliosis. It is associated with pain in individuals without scoliosis, but it is not known whether this association holds among persons with scoliosis. Magnitude of trunk list is correlated with magnitude of Cobb angle and there may be an association between trunk list and curve progression.

Methods: We measured trunk list on 55 participants with idiopathic scoliosis using a plumbline. Type of scoliosis was recorded and Cobb angle was measured on radiographs taken on the same day. The participants answered the Scoliosis Research Society-22 patient questionnaire that addresses pain, self-image and mental health. Pearson correlations were calculated between trunk list and pain, Cobb angle, self-image and mental health. We then used multiple linear regression models to determine associations between these variables. We also used logistic regression models to describe trunk list as a function of Cobb angle, pain and scoliosis type.

Results: Trunk list is positively correlated with Cobb angle ($r=0.32$, $p=0.02$) but it was not correlated with pain, mental health, self-image, or type of scoliosis. However, in the logistic regression models, there was a tendency for trunk list to be associated with lower pain.

Conclusions: Our study highlights the importance of the clinical measurement of trunk list. Further research should explore the treatment of trunk list and its ramifications on Cobb angle and pain.

Significance: This study suggests that trunk list is associated with Cobb angle. Postural treatment of trunk list may have an impact on Cobb angle.
Keywords: trunk list, scoliosis, lateral trunk shift, pain, Cobb angle, self-image, mental health

Introduction

Trunk list, or lateral deviation of the spine, is a common trait seen in approximately 55% of individuals with IS[10]. Trunk list has been suggested to lead to the development and progression of scoliotic curves[24, 26] and is therefore an important component of the evaluation in IS. Although very prevalent and commonly evaluated in this population, only a few studies examine the relationships that exist between trunk list and other aspects of scoliosis, including Cobb angle, type of scoliosis, pain, mental health and self-image.

In the general population, trunk list has been associated with back pain[18, 23, 107-109]. Reducing trunk list using reverse trunk list exercises and reverse trunk list traction (i.e. the Harrison treatment method) seems to decrease pain in persons with low back pain[1]. In the cases of IS, less is known with regards to the relationship between pain and trunk list. Between 50 and 71 % of adolescents with IS present with back pain[31, 35, 36] and although back pain is not typical in those with mild IS, it can be associated with curve progression[38]. One study showed that adults with trunk list greater than 4 cm who had unoperated scoliosis had increased pain[23]. In a cohort study of 2442 youths with IS, there was no significant difference in pain experienced between the 220 individuals with trunk list greater than 1cm and the others[19]. However, the p value was 0.052; these results have never been challenged or duplicated.

The Cobb angle is the gold standard with regards to monitoring scoliosis progression[53]. A correlation between Cobb angle and trunk list exists in healthy individuals who assume a trunk list[26]. However, to our knowledge, no studies have examined the relationship between Cobb angle and trunk list in those with IS.

Type of scoliosis is considered a prognostic factor in IS[25] and is therefore an important consideration for clinicians evaluating IS. Gauchard et al.[21] found a relationship between trunk list and the type of scoliotic curves. They found that those with double major curvatures had the smallest trunk list, followed by thoracic curves, then thoracolumbar curves and finally lumbar curves. Gram and Hasan [22] showed that trunk list is greater in lumbar curves than in thoracic curves.

Adolescents with IS are more likely to exhibit poor mental health [35, 42, 44] and self-image [42, 45, 46], which are both associated with curve magnitude [35, 42]. There is no consensus in the literature concerning the association between trunk list and well-being among persons with IS. Some studies show no correlation between trunk list and quality of life [12] and self-image [43]. However, Glassman et al. [23] found that adults with unoperated scoliosis with trunk list greater than 4cm have a poorer functional level.

The objective of this study was to explore the association between trunk list and the following factors: Cobb angle, type of scoliosis, pain, mental health and self-image. A secondary objective was to explore various associations between the previously mentioned variables. We hypothesized that trunk list would be correlated with pain, Cobb angle (single curvatures more so than double curvatures) and with self-image.

Materials and Methods

Fifty-five (55) participants (47 female, 8 male), aged 10 to 19 years presenting with IS (Cobb angle between 10° and 60°) were recruited from a scoliosis clinic at a tertiary care paediatric hospital. Mean age of participants was 14.5 years ±2.2 years and average weight and height 53.4 ± 9.6 Kg and 162.2 ± 9.9 cm, respectively. We excluded participants who had had a back surgery or who had a leg length discrepancy greater than 1.5cm. All participants and their parents signed informed consent forms and the project was approved by the institutional ethics committee.

Trunk list was measured on the participants using the plumbline by a trained professional four times with feet in a "V" position at an angle of 30°. Cobb angle was measured on radiographs taken on the same day by a radiologist or orthopedic physician. Type of scoliosis was designated in four categories: double major, thoracic, thoracolumbar or lumbar. This was done by a trained professional who evaluated the location of the curve apex or apices on radiographs taken on the same day.

Participants answered the Scoliosis Research Society Outcomes Instrument SRS-22 questionnaire, which addresses pain, mental-health and self-image. This questionnaire was developed as a scoliosis-specific, simple questionnaire for patients with IS [65], to evaluate health related quality of life [110]. It is a patient-based questionnaire, taking into account not only objective measures of a patient's medical condition, but also the patient's self-perception of his/her condition. The questionnaire has evolved and now includes 22 questions (SRS-22) covering five domains: pain, function, self-perceived image, mental health and satisfaction with management. It has been modified into many languages, including a cross-cultural French Canadian adaptation (SRS-22vf) [66], which was used in this study. It has very good overall reliability (Cronbach $\alpha = 0.86$) and high concurrent validity of 0.79 when compared with the SF-12 for the total scores. The SRS-22vf showed moderate ceiling effects in the pain and satisfaction with management domains. The psychometric properties observed in the SRS-22vf are consistent with results shown in the original version [66]. The SRS-22 addresses pain with five questions regarding pain intensity, pain at rest, function affected by pain and management with medication. Self-image is addressed with five questions regarding happiness with self, appearance, specifically trunk appearance, relationships and perceived attractiveness to others. Finally, mental health is addressed with five questions concerning nervousness, depression, calmness, discouragement and happiness. Each domain has 5 corresponding questions, which are summed to obtain a score out of 5; 5 being the highest and 0 being the poorest health-related quality of life.

Statistical Analysis

We calculated the mean of the four trunk list measurements. We then computed Pearson correlation coefficients between trunk list and pain, Cobb angle, mental health and self-image. We assessed whether trunk list varied among the different types of scoliosis using the Chi-square (χ^2) test and analysis of variance (ANOVA) and compared means of double versus single curvatures using the unpaired samples t-test.

We constructed multiple linear regression models to explore various associations. These were: 1) trunk list as a function of Cobb angle, pain and scoliosis type; 2) pain as a function of mental health, Cobb angle and trunk list; 3) self-image as a function of trunk list, Cobb angle and mental health; and 4) mental health as a function of pain, trunk list and self-image. Type of scoliosis was designated as single versus double for the purposes of the analyses. We also used logistic regression models to describe trunk list (as a dichotomous outcome using several cutoffs: 1cm, 1.5cm and 2cm) as a function of Cobb angle, pain and scoliosis type. This was done because because individuals with trunk list greater than 1 cm have a poorer scoliotic prognosis [2] and for comparison purposes since Ramirez et al. [19] used the same cut-off in their study and others have used higher cut-offs[23].

Results

Mean trunk list measurement was 13.7 ± 7.5 mm; median was 12.75 mm and inter-quartile range was from 7.25 to 18.25 mm. Mean scores for pain, self-image and mental health were approximately 4/5, indicating a low degree of pain, and high degrees of self-image and mental health (see Table 3 for details).

Trunk list was significantly correlated with Cobb angle (r = 0.32, p=0.02). Trunk list was not associated with type of scoliosis (χ^2 = 0.18, p = 0.69); no difference existed between double and single curve types (12.9 mm versus 13.9 mm, p = 0.26). There were no significant correlations between trunk list and pain, mental health or self-image (Table 4). We found that lower self-image correlated with higher Cobb angles (r = 0.47, p =

0.00); lower pain correlated with lower Cobb angles (r = 0.29, p = 0.03), higher self image (r = 0.44, p = 0.00) and higher mental health (r = 0.47, p = 0.00); and higher mental health correlated with higher self image (r = 0.46, p = 0.00).

Multiple linear regression models are described in Table 5. These models demonstrate that larger trunk lists are associated with larger Cobb angles. Higher Cobb angles are also associated with higher levels of pain and lower perceptions of self-image. Higher levels of mental health are associated with less pain and higher self-image. The logistic regression models showed no significant associations between pain or type of scoliosis in trunk lists >1cm, >1.5cm. However, in the model with trunk list >2cm, trunk list was associated with Cobb angle and there was a tendency (although the 95% confidence interval included 1) for trunk list to be associated with higher score on the pain scale (i.e. lower amount of pain) (see Table 6).

Discussion

The objective of our study was to determine whether trunk list was associated with Cobb angle, type of scoliosis, pain, mental health and self-image in adolescents with IS. We used the plumbline method to measure trunk list because it is part of the habitual clinical assessment in persons with IS. In a previous study[111], our research team showed that the plumbline is both a valid and reliable method to evaluate trunk list.

Our results suggest that trunk list is positively correlated with Cobb angle in individuals with IS. Harisson et al.[26] have also reported a significant correlation between the degree of trunk list and Cobb angle in healthy individuals who assume a trunk list. As previously mentioned, the relationship between trunk list and Cobb angle has been suggested to be associated with the risk of scoliosis progression and/or development[26]. Some suggest that a scoliotic curve begins with a side bending posture, which progresses by causing increased loads, vertebral growth alterations and more postural alterations[24]. Therefore, it is possible that trunk list contributes to the development and progression of scoliosis[26].

We did not find a relationship between trunk list and curve type. This is in contrast with other studies. According to Gauchard et al's study[21], trunk list was significantly different between double and single curves. It was smallest in double major curves. In single curvatures, trunk list was smaller in curves that were higher on the back (thoracic < thoracolumbar < lumbar). Gram and Hasan[22] have also reported similar results. The discrepancy between the results of our study and previous studies may be explained by the small sample size of our double curves group (n=11).

We found no relationship between trunk list and pain when we used trunk list as a continuous variable. However, when we dichotomized trunk list at 2 cm, there was a tendency towards association between pain and trunk list – i.e. trunk list above 2cm appeared to be associated with less pain. Although this was not expected, we hypothesize that trunk list could be explained as an antalgic posture, i.e. a posture assumed in order to reduce pain[6]. This is in contrast to the results of Glassman[23], who showed that those with trunk list greater than 4cm experienced more pain. In our cohort, there were no individuals with trunk list greater than 4cm. The relationship between trunk list and back pain is also a source of debate in those without IS. The mechanism of trunk list has been presumed to be a means of assuming a position that puts the least amount of strain on the surrounding structures in individuals with disc herniation[112]. Assuming a position that decreases strain on the spine may explain our results in individuals with IS. However, Arangio et al.[108] found no correlation between trunk list and low back pain and found no change in trunk list before and after surgical intervention (which alleviated pain). These findings suggest that there may be a threshold beyond which trunk list is associated with increased pain whereas below that threshold it may be a posture that is assumed to avoid pain.

The lack of correlation between trunk list with mental health and with self-image supports the results of Mac-Thiong et al.[12], who found that trunk list under 4cm is not associated with changes in quality of life and the results of Watanabe et al.[43], who found no correlation between trunk list and self-image. Another study showed that adults with unoperated scoliosis presenting with trunk list greater than 4cm have a lower functional level and increased pain[23]. Our study does not negate these results because our cohort did not include individuals with trunk list greater than 4cm.

There are several limitations to our study. These include the small sample size and low variation in trunk list (i.e. none greater than 4 cm). The SRS-22vf has a ceiling effect in the pain domain, which may have limited its measurement in this case. Since the majority of our subjects had a low level of pain, which is a high pain score on the SRS-22vf scale, there may have been differences in pain experienced that were not picked up by this questionnaire.

The association between trunk list and Cobb angle may suggest that trunk list can be used as an indicator of scoliosis severity. Furthermore, perhaps its treatment can produce positive results. Administration of side-shift exercises, which focus on reversing trunk lists, yield similar results to bracing, namely maintaining or even decreasing scoliotic curves[69, 113, 114]. Therefore the treatment of trunk list, especially in its early stages, should be further explored in order to potentially halt the progression and development of scoliosis.

Conclusion

There exists a relationship between trunk list and Cobb angle, which must be further explored to determine if the former leads to the latter. Our findings highlight the importance of the clinical measurement of trunk list as a non-invasive measurement to determine potential risk of progression in individuals with IS. Further research should be done with regards to implications of the treatment of trunk list on both Cobb angle and pain.

Table 3: Descriptive results of cohort of adolescents with IS (n=55)

		Mean (SD)	Range
Trunk List Measurement (mm)			
All participants (n=55)		13.7 (7.5)	4.00 - 35.75
Double major curve (n=11)		12.9 (6.5)	4.00 – 22.75
Thoracic curve (n=27)		12.9 (6.8)	4.25 – 31.50
Thoraco-lumbar and lumbar curve (n=17)		15.5 (9.1)	5.50 – 35.80
Cobb Angle			
All participants		30° (17°)	10° - 65°
Double major curve		34° (16°)	11°- 52°
Thoracic curve		34° (17°)	10° - 64°
Thoraco-lumbar and Lumbar curve		23°(14°)	10° - 65°
SRS domain	Pain	4.1 (0.69)	2.2 – 5.0
	Self Image/Appearance	3.8 (0.83)	1.7 – 5.0
	Mental Health	4.0 (0.60)	2.4 – 5.0

Table 4: Pearson Correlations between Trunk List and Cobb Angle, Pain, Mental Health and Self-Image.

	Cobb Angle	Pain (SRS)[1]	Mental Health[2]	Self-Image[3]
Trunk list	*0.32 p=0.02*	0.11 p=0.42	-0.04 p=0.77	-0.15 p=0.27

1 Pain was measured on the French version of the Scoliosis Research Society Outcomes Instrument 22(SRS-22vf). Higher values indicate less pain.
2 Mental Health was measured on the French version of the Scoliosis Research Society Outcomes Instrument 22(SRS-22vf). Higher numbers indicate better mental health
3 Self-image was measured on the French version of the Scoliosis Research Society Outcomes Instrument 22(SRS-22vf). Higher numbers indicate better self-image.

Table 5: Linear Regression models describing factors that contribute to trunk list, pain, self-image and mental health.

	Factor	**Beta Coefficients (95%CI)**	**P values**	**R^2**
Trunk list	*Cobb**	0.17 (0.04, 0.29)	0.01	0.14
	Pain	2.22 (-0.82, 5.27)	0.15	
	Type**	-0.98 (-5.97, 4.01)	0.70	
Pain	Trunk list	0.02 (-0.003, 0.042)	0.08	0.32
	*Cobb**	-0.01 (-0.023, -0.002)	0.02	
	*Mental Health**	0.52 (0.245, 0.792)	0.00	
Self-Image	Trunk list	-0.002 (-0.026, 0.025)	0.99	0.39
	*Cobb angle**	-0.02 (-0.033, -0.010)	0.00	
	*Mental Health**	0.57 (0.260, 0.885)	0.00	
Mental Health	Trunk list	-0.003 (-0.022, 0.017)	0.80	0.31
	*Pain**	0.30 (0.066, 0.528)	0.01	
	*Self-image**	0.22 (0.026, 0.411)	0.03	

* P <0.05
** Type of scoliosis was designated as double or single

Table 6: Factors associated with Trunk List in logistic regression models of Trunk List dichotomized at 1cm, 1.5 cm and 2 cms.

	Trunk List > 1cm Odds Ratio (95% CI)	Trunk list > 1.5cm Odds Ratio (95% CI)	Trunk list > 2cm Odds Ratio (95% CI)
Cobb angle	1.015 (0.980, 1.052)	1.031 (0.994, 1.069)	*1.076 (1.017, 1.139)*
Pain	1.049 (0.447, 2.465)	1.330 (0.553, 3.200)	4.317 (0.992, 18.77)
Type of scoliosis*	1.192 (0.293, 4.853)	1.515 (0.373, 6.144)	0.622 (0.055, 6.992)

*Type of scoliosis was designated as double or single

Chapter 7: Additional Results

7.1 Bland and Altman

In addition to the analyses described in the two manuscripts, the Bland and Altman analysis was conducted to describe agreement between the plumbline measure (clinical measurement of trunk list) and measurement on radiographs. This analysis directly compares the values obtained using both the plumbline and radiographic measurements, by plotting the mean of the two measurements versus the difference. The mean, maximum and minimum differences are calculated; the closer these values are to zero, the closer the sample is to perfect agreement[102].

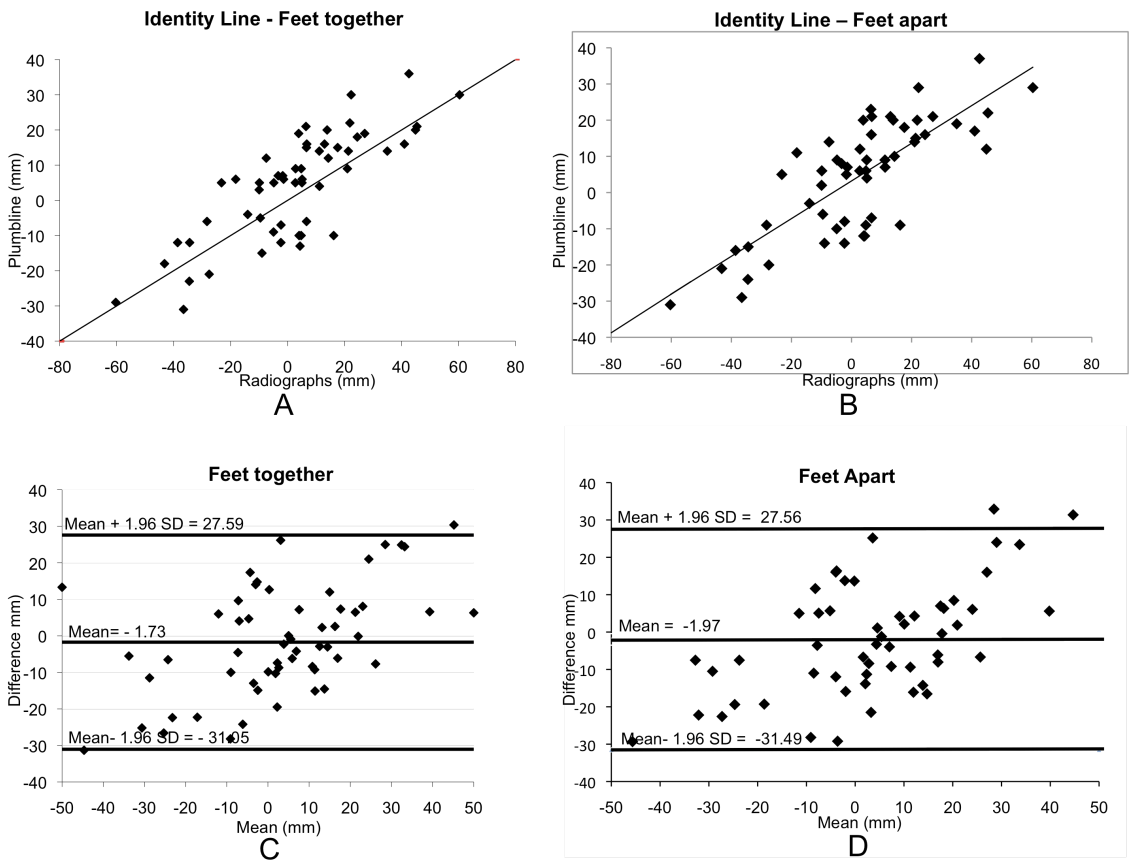
The Bland and Altman analysis shows mean differences between the clinical and the radiograph measurement of trunk list from 1.73 to 1.97 mm (see Table 7). Table 7 shows the mean ±1.96SD of the difference of the 2 measurements and Figure 3 is a graphic representation of the distribution of this data. As reported in Table 7 and illustrated in Figure 4, the 95% limits of agreement (mean difference ±1.96SD) are wide for both clinical methods FT and FA indicating a lack of agreement between the clinical methods and the radiograph method.

Table 7 Validity: Bland and Altman limits of agreement for trunk list measurement between the two clinical methods in the two foot positions and radiographs

Clinical methods	Bland and Altman limits of agreement with radiographs ± 2SD
Plumbline	
- Feet together	-1.73 ± 29.32
- Feet apart	-1.97 ± 29.53

All correlation coefficients were statistically significant $p < 0.05$

Figure 4*: Validity analysis showing identity lines comparing PL-FT versus radiographs (A), PL-FA versus radiographs (B) and showing Bland and Altman plots (C, D) - the average of radiographs and plumbline against differences between these two methods for FT and FA respectively.*



7.2 Additional Correlations

In manuscript 2 the correlation between trunk list and Cobb angle, pain, type of scoliosis, mental health and self-image were described. Additional correlations between the different factors were computed. Table 8 shows the correlation matrix that includes trunk list, Cobb angle, pain, mental health and self-image. Lower self-image correlated with higher Cobb angles ($r = 0.47$, $p = 0.00$); lower pain correlated with lower Cobb angles (r = 0.29, p = 0.03), higher self image (r = 0.44, p = 0.00) and higher mental health (r = 0.47, p = 0.00); and higher mental health correlated with higher self image (r = 0.46, p = 0.00).

Table 8: Correlation matrix between the following variables: trunk list, Cobb angle, pain, mental health and self-image

	Trunk List	Cobb Angle	Pain	Mental Health	Self-Image
Trunk List	1.00				
Cobb Angle	0.32	1.00			
Pain	0.11	-0.29	1.00		
Mental Health	-0.04	-0.12	0.47	1.00	
Self-Image	-0.15	-0.47	0.44	0.46	1.00

Chapter 8: Discussion

In this section, the results of this research study will be summarized and the additional results not discussed in the articles will be presented. Trunk list and the amount of trunk list that can be considered normal will be further explored. Finally, the clinical implications of trunk list and future research directions will be explored.

8.1 Summary of Results

The main objectives were to determine the reliability and validity of the plumbline and photographic methods in the measurement of trunk list, as well as to determine whether associations exist between trunk list and pain, Cobb angle, type of scoliosis, mental health and self-image. The results pertaining to these objectives are summarized below.

8.1.1 Reliability

The results of our study indicated that the plumbline (φ = 0.97-0.99) and photography (φ =0.87-0.98) are both reliable methods to measure trunk list, however the photographic method had larger SEM values. These results hold true regardless of foot position.

8.1.2 Validity

In our study, we showed that the plumbline is a valid method to measure trunk list, comparing to the gold standard of radiographic measurement of trunk list (r = 0.83).

Photography is also a valid method to evaluate trunk list (r = 0.78), however its validity of slightly lower than that of the plumbline. Foot position did not affect validity.

8.1.3 Agreement

Mean differences between the clinical and radiographic measurement of trunk list ranges from 0 to 1.97 mm. The 95% limits of agreement are wide for both clinical methods, indicating a lack of perfect agreement between the clinical and radiographic method.

8.1.4 Correlations and associations

A correlation between trunk list and Cobb angle was shown (r = 0.32). No correlation or association was found between trunk list and pain, type of scoliosis, mental health or self-image. However, trunk list >2cm, although not statistically significant, appears to be associated with lower pain.

Lower self-image correlated with higher Cobb angles (r = 0.47, p = 0.00); lower pain correlated with lower Cobb angles (r = 0.29, p = 0.03), higher self image (r = 0.44, p = 0.00) and higher mental health (r = 0.47, p = 0.00); and higher mental health correlated with higher self image (r = 0.46, p = 0.00).

8.2 Discussion of Additional Results

8.2.1 Agreement between the clinical and radiographic measures

In agreement with previous studies[13, 16], both the plumbline and photographic methods showed good concurrent validity with measurement of trunk list taken on radiographs. Despite the good level of validity found with Pearson correlation coefficients for the two clinical methods (plumbline and photography), the wide limits of agreement found in the Bland and Altman analysis demonstrate that trunk list measurement calculated by these methods differs from the radiographic measurement. The differences between these two techniques may be attributable to the measurement method. In both clinical methods, trunk list was measured from the spinous processes whereas in the radiographic method, trunk list was measured from the centre of the vertebral body. Although we may assume that the spinous process and the centre of the vertebral body are in the same location in the horizontal plane, due to rotation of the spine in scoliosis, the spinous process may not actually be located in the same horizontal location as the vertebral body. The differences between these two methods may also be attributed to other factors, namely the curve type and pain. Sixty-four percent (64%) of participants who exhibited a difference in sign (+/-) in the radiographic versus plumbline values had thoraco-lumbar or lumbar scoliosis as opposed to 37% of participants with same sign values ($p < 0.05$). Several authors demonstrate an increased postural sway in persons with thoraco-lumbar and lumbar scoliosis as well as in persons with low back pain, which may explain the aforementioned results[21, 115-117]. The discrepancy between the radiographic and clinical results indicate that the 2 methods should not be used interchangeably; if the clinical measure is used in the evaluation of trunk list, then this should be used at follow-up evaluations.

8.2.2 Additional Correlations

A weak correlation was found (r = 0.3) between pain and Cobb angle, which is similar to results from other studies (r ranging between 0.32-0.37)[41-43]. However some show conflicting results. Ramirez and associates[19] compared Cobb angle in 2442 individuals with IS and found no difference in pain between the two groups. Danielsson and associates[39] investigated 156 adults 20 years post spinal fusion for scoliosis and found no association between pain and Cobb angle, yet this study was investigating adults who had undergone surgery. Finally, Weinstein and associates[118] evaluated 194 adults and found that backache was not associated with curve severity. Although the relationship between pain and curve severity is debatable, it seems as though individuals with AIS have increased pain compared to controls[42, 119, 120], although it is not a factor that limits function[121].

A correlation between Cobb angle and self-image was found (r = -0.47) but none was found between Cobb angle and mental health (r = -0.12). Asher et al.[42] showed correlations between Cobb angle with both self-image and mental health, however the relationship between self-image and Cobb angle (r = -0.50) was much greater than that between mental health and Cobb angle (r = -0.27). The sample size of their study (n=119) was greater than that of this present study (n=55), which may possibly explain the difference in correlation and significance between Cobb angle and mental health found in their study but not in the present study.

The relationship between pain and quality of life has been noted repeatedly[122, 123]. The present study confirms the relationship between 2 aspects of quality of life, namely mental health (r = 0.47) and self-image (r = 0.44) with pain.

8.3 Trunk list normative value

It is likely that if individuals without spinal conditions were evaluated, some would present with trunk list, however no research exists regarding trunk list in the general population. Therefore, the amount of trunk list is considered normal and what amount could be considered pathological is unknown. In 1941, a study of individuals with scoliosis found that 55% presented with trunk list, but of that 55%, 71% presented with trunk list less than 1.27 cm (0.5 inch)[10]. Being small and also representing >70% of trunk list in persons with scoliosis, we wonder if this value (1.27cm) can be considered within the normal range. The results of the present study do not answer the question, but they do help guide us. Using logistic regression analysis, we found that trunk list >2cm was associated with Cobb angle and was almost significantly associated with pain. Others have shown that 1cm is a significant point. With trunk list greater than 1 cm, an individual with scoliosis has a poorer prognosis[2]. Ramirez found no relationship between pain and trunk list greater than 1 cm, however the p-value was "borderline" at p = 0.052[19]. Perhaps had they used a cutoff greater than 1 cm, they would have found significant results. Both these studies do not explain their choice of 1 cm, rather it appears to have been arbitrary[2, 19]. Despite being arbitrary, there appears to be a clinical difference when trunk list increases. However, it is unknown whether this difference would be more substantial if another value was chosen. In the case of the current study, the number of individuals was too small to investigate this further by dividing the cohort into groups with trunk lists of magnitudes greater than 2cm.

Another trunk list value that appears to be significant in the literature is 4cm. Glassman et al.[23] showed that individuals with trunk list greater than 4 cm had increased pain and decreased quality of life. However, MacThiong et al.[12] found no correlation between trunk list and quality of life in individuals with trunk list less than 4cm. Due to the present study's smaller sample size, this could not be corroborated as no individuals with trunk list greater than 4cm were investigated.

To determine what amount of trunk list is considered normal, a normative study of the population at large should be done to look at amount of trunk list in the general population.

8.4 Clinical Implications

This study has shown that the clinical evaluation of trunk list using the plumbline and photographs are both reliable and valid methods. However, the reasons to measure trunk list are still unclear. Therefore, in this section, the implications of trunk list in the clinical setting are explored.

Risk of progression of scoliosis is a critical component with regards to treatment planning for individuals with IS. Risk factors for progression, including age, physical maturity level, sex, curve size and curve pattern, are all taken into account by clinicians[27]. Trunk list has been suggested to be associated with poorer scoliosis prognosis and may lead to scoliotic curve progression[2, 4-6]. Trunk list, due to increased loads on the spine, may lead to an associated rotation of the spine and therefore a scoliotic curve[24]. As well, administration of side-shift exercises, which focus on reversing trunk lists, yielded similar results to bracing, namely maintaining or even decreasing scoliotic curves[69, 114], which indicates that correcting trunk list may have an influence on curve severity in IS. However, one study[52] showed that absence of trunk list was actually related to scoliosis progression. These conflicting results indicate that there is still a gap in knowledge regarding trunk list and scoliosis progression. A possible explanation may be related to the relationships between trunk list, pain and curve severity (Cobb angle). Pain has been suggested to be linked to curve progression[38] as is Cobb angle[25]. Higher pain was found to be associated with higher Cobb angle and Cobb angle and trunk list are positively correlated. As trunk list increased to 2cm, the confidence interval between trunk list and pain almost attained statistical significance. There may be a threshold value beyond which trunk list is associated with curve progression. If so, this relationship may not have been evident in the present study since its sample did not contain those with very high degree of trunk list (our range was 1.5 to 38mm). A longitudinal study is needed with a larger sample in order to determine the prognostic value of trunk list in AIS.

Pain is always an important factor with regards to the clinical evaluation of a patient with any diagnosis. Although subjective, it can significantly affect the daily life of individuals and is critical to evaluate[124]. Glassman et al.[23] found that trunk list greater than 4cm was associated with increased pain in adults with IS. Porter et al.[18] also found a positive association between trunk list and pain, however this was in individuals without scoliosis. However, one author explains that pain is what may lead to an initial trunk list posture and that trunk list may be a means of pain relief, or an antalgic posture[6], implying that trunk list may be negatively correlated with pain. This may explain the lack of relationship found in our study; those who exhibited higher pain together with lower trunk list may have offset those who exhibit and positive relationship between their pain and trunk list. These contradictory studies indicate that more research must be done to investigate trunk list. Perhaps in some cases trunk list is a means of pain relief and in other cases it is positively associated with pain. Clinicians must determine whether trunk list is a means of pain relief (i.e. higher trunk list associated with lower pain) or if trunk list is an indicator of pain (i.e. higher trunk list associated with higher pain) in order to guide treatment.

In a clinical setting, if pain and trunk list both increase in a patient, then perhaps this is a case where addressing the trunk list with a specific treatment protocol can address the pain. However, when a patient presents with no pain in a side-shifted position, yet has pain when correcting his/her posture, then perhaps this is a case where there is an underlying cause to the pain that is leading to an antalgic or trunk list posture, which should be addressed.

8.5 Future Research Directions

In this section, future research directions that will improve the knowledge base regarding trunk list are discussed, allowing for better understanding in clinical settings.

The present study has brought forward new avenues of research that should be explored regarding trunk list in individuals with IS.

With regards to psychometric properties, although it is known that the plumbline and the photographic method are both reliable and valid in the measurement of trunk list, it is unknown whether these methods are sensitive to change over time. Therefore a longitudinal study should be done to determine whether the plumbline and/or photograph measurements of trunk list are sensitive to change over time. If the plumbline and photographic measurements are sensitive to change, clinicians will be able to use the trunk list measurement to track changes over time in patients with IS.

A longitudinal study can also examine trunk list and its relationship to scoliosis curve progression. As previously discussed (Section 8.4), there are inconsistencies and contrasting opinions with regards to trunk list being a risk factor for scoliotic curve progression. Furthermore, a longitudinal study will allow for the study of the temporal relationship between pain and trunk list, so that clinicians and researchers may better understand the cause and effect relationship[6].

Researchers should also explore the physiotherapeutic treatment of trunk list and its effect on pain, scoliosis progression and curve severity. If the treatment of trunk list has a positive effect on pain and scoliosis, this clinical measurement of scoliosis will be considered an important indicator of progression/regression.

Another important research goal is to discover a trunk list normative value by studying trunk list in the population at large, who do not have any underlying postural disorders or back pain. This will allow the determination of what is normal and what is pathological and therefore researchers would be able to focus on the latter in the previously mentioned studies.

Chapter 9: Conclusion

Trunk list is a clinical measurement commonly used when evaluating individuals with IS, as well as other postural conditions. In the first manuscript presented in this thesis, the plumbline and photographic methods are shown to be both reliable and valid in the assessment of trunk list with the individual's feet together or apart. However, the subsequent Bland and Altman analysis showed that the clinical measurement cannot be used interchangeably with radiographs. These authors suggest that clinicians use one or the other consistently to measure trunk list on their patient.

The second manuscript presented in this thesis demonstrated that trunk list is correlated with Cobb angle, yet it is not associated with pain, type of scoliosis, mental health or self-image. The correlation that was found between trunk list and Cobb angle does not provide a full understanding of this relationship, yet it is indicative of trunk list being clinically important in IS. Further longitudinal research should examine the relationship between trunk list and scoliosis progression over time.

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Appendix A : Ethics Approval

Le 22 septembre 2010

Madame Carole Fortin
46 Chemin des Hirondelles
Morin-Heights (Québec) J0R 1H0

OBJET: Titre du projet: Fidélité et validation de la mesure clinique du déjettement du tronc aurpès d'enfants et d'adolescents présentant une scoliose idiopathique

No. de dossier: 2949

Responsables du projet: Carole Fortin Ph. D., chercheure responsable au CHU Sainte-Juatine. Chercheure principale: Debbie Feldman. Collaboratrice: Erin Grunstein

CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant

Pour l'amour des enfants

Université de Montréal

Madame,

Votre projet cité en rubrique a été réapprouvé par le comité d'éthique de la recherche en date du 17 septembre 2010. Vous trouverez ci-joint la liste des documents approuvés ainsi que votre formulaire d'information et de consentement estampillé dont nous vous prions de vous servir d'une copie pour distribution.

Tous les projets de recherche impliquant des sujets humains doivent être réexaminés annuellement et la durée de l'approbation de votre projet sera effective jusqu'au **17 septembre 2011**. Notez qu'il est de votre responsabilité de soumettre une demande au Comité pour le renouvellement de votre projet avant la date d'expiration mentionnée. Il est également de votre responsabilité d'aviser le Comité de toute modification à votre projet ainsi que de tout effet secondaire survenu dans le cadre de la présente étude.

Nous vous souhaitons bonne chance dans la continuité de votre projet et vous prions de recevoir nos meilleures salutations.

Jean-Marie Therrien
Président du Comité restreint du CÉR

JMT/cp

3175, Côte-Sainte-Catherine
Montréal (Québec)
H3T 1C5

Liste des documents approuvés par le CÉR

CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant

Pour l'amour des enfants

Université de Montréal

Titre du projet:
Fidélité et validation de la mesure clinique du déjettement du tronc aurpès d'enfants et d'adolescents présentant une scoliose idiopathique

No. de dossier: 2949

Date de réapprobation : vendredi 17 septembre 2010

Responsables du projet: FORTIN CAROLE Ph. D., chercheure responsable au CHU Sainte-Juatine. Chercheure principale: Debbie Feldman. Collaboratrice: Erin Grunstein

Liste:

- Protocole de recherche non daté, réapprouvé le 17 septembre 2010
- Formulaire d'information et de consentement non daté, réapprouvé le 17 septembre 2010

3175, Côte-Sainte-Catherine
Montréal (Québec)
H3T 1C5

Appendix B : Consent Form

FORMULAIRE D'INFORMATION ET DE CONSENTEMENT

TITRE DU PROJET DE RECHERCHE

Fidélité et validité de la mesure clinique du déjettement du tronc auprès d'enfants et d'adolescents présentant une scoliose idiopathique.

NOMS DES CHERCHEURS ET COLLABORATEURS

Debbie Feldman, pht, Ph.D[2], Carole Fortin, pht, Ph.D. (c)[1], Hubert Labelle, M.D.[1]
Stefan Parent, M.D., Ph.D.[1], Erin Grunstein, pht[2]
1. CHU Sainte-Justine, 2. École de réadaptation, Université de Montréal.

SOURCES DE FINANCEMENT

Subvention en partenariat de l'Ordre professionnel de la physiothérapie du Québec et du Réseau provincial de recherche en adaptation-réadaptation (OPPQ-REPAR).

INVITATION À PARTICIPER À UN PROJET DE RECHERCHE

Le service d'orthopédie du CHU Sainte-Justine participe à des protocoles de recherche dans le but d'améliorer les outils d'évaluation et les méthodes de traitement chez les enfants qui présentent une scoliose idiopathique. Nous sollicitons aujourd'hui votre participation à ce projet. Nous vous invitons à lire ce formulaire d'information afin de décider si vous êtes intéressés à participer à cette étude. Il est important de bien comprendre ce formulaire. N'hésitez pas à poser des questions. Prenez le temps nécessaire pour prendre votre décision.

NATURE DE CETTE RECHERCHE

Votre enfant présente une scoliose idiopathique. Cette condition entraîne des modifications de la posture. Une des mesures cliniques fréquemment utilisée pour vérifier l'impact de la scoliose sur la posture est la mesure du déjettement du tronc. Cette mesure clinique est habituellement prise à l'aide d'un fil à plomb et correspond à la distance entre la tombée de ce fil placé sur un repère osseux à la base du cou (C7) et le pli inter-fessier. Cette mesure est partie intégrante du bilan clinique lors de la visite de votre enfant en orthopédie et permet de vérifier si la posture de votre enfant s'est aggravée. Cependant, jusqu'à présent, aucune étude n'a rapporté la fidélité et la validité de cette mesure clinique auprès d'enfants et d'adolescents présentant une scoliose idiopathique.

OBJECTIFS DU PROJET

Nous invitons votre enfant à participer à ce projet de recherche qui vise 1) à vérifier la fidélité de la mesure clinique du déjettement du tronc prise manuellement d'un essai et d'une occasion à l'autre; 2) à valider cette mesure clinique en la comparant à la mesure radiologique; 3) à comparer cette mesure manuelle à celle obtenue à partir de photographies; 4) à vérifier l'impact de la position des pieds sur la reproductibilité des mesures et 5) à établir le lien entre le déjettement du tronc et, le type et l'importance de la scoliose, la présence de douleur et la perception que votre enfant a de sa posture.

DÉROULEMENT DU PROJET DE RECHERCHE

La participation de votre enfant à cette étude n'affectera pas son état de santé. Deux séances espacées d'une heure sont nécessaires pour compléter l'étude. Cette étude sera réalisée pendant que votre enfant attend pour son rendez-vous de contrôle à la clinique de scoliose. Cette visite permettra d'évaluer le déjettement du tronc de votre enfant. L'évaluation sera effectuée en position debout. Cette évaluation correspond à celle qui est habituellement faite par le médecin ou le physiothérapeute qui soigne votre enfant. Plus précisément, deux collants seront posés sur le dos de votre enfant par une physiothérapeute (un à la base du cou – C7 et l'autre au-dessus du pli inter-fessier – S1). La physiothérapeute va mesurer la distance entre la tombée du fil à plomb (mis sur C7) et le pli inter-fessier avec une règle rigide conventionnelle. Une photographie du dos de votre enfant sera par la suite prise par une caméra numérique (pieds en « V » à 30°). Nous demanderons à votre enfant de faire quelques pas et une deuxième série de mesures sera prise de la même façon (avec le fil à plomb et photographie). Cette même procédure sera refaite dans une deuxième position (pieds écartés) pour voir si une position est plus reproductible que l'autre. Après cela, nous demanderons à votre enfant de revenir environ une heure plus tard pour refaire le même protocole avec la physiothérapeute (pour vérifier si l'évaluateur est constant d'une fois à l'autre). Chaque séance durera environ 15 minutes et votre enfant pourra se reposer si nécessaire. L'évaluation faite par le système de caméras et les rayons-x permettront de valider l'évaluation clinique faite manuellement par les médecins et les physiothérapeutes. Entre les deux évaluations, nous demanderons à votre enfant de répondre aux questions de deux questionnaires pour une durée maximale de 15 minutes. Le premier nous renseignera sur la condition médicale de votre enfant et concernera ses antécédents médicaux et familiaux, ses autres problèmes de santé s'il y a lieu et le traitement actuel pour la scoliose. Le second nous permettra de vérifier l'impact de la présence d'une scoliose sur la qualité de vie de votre enfant (par exemple la perception de sa posture et de son dos, ses habitudes de vie et la présence de douleur). Les chercheurs consulteront le dossier médical de votre enfant notamment pour utiliser les rayons-x pris lors du suivi clinique de l'enfant. La visite aura lieu dans une salle d'évaluation du CHU Sainte-Justine situé à proximité de la clinique d'orthopédie. Il est important de vous spécifier qu'aucune des mesures n'implique des piqûres.

AVANTAGES ET BÉNÉFICES

Pour votre enfant

Il est impossible de prédire si vous votre enfant retirera des bienfaits pour sa santé en participant à cette recherche. Toutefois, votre médecin ou physiothérapeute pourra utiliser les renseignements recueillis pour planifier la conduite de son traitement.

Pour les personnes qui ont une scoliose idiopathique

Grâce aux résultats obtenus sur l'ensemble des sujets, il sera possible de valider l'évaluation clinique du déjettement du tronc habituellement faite par le médecin ou le physiothérapeute. Cette étude permettra également de vérifier si cette mesure peut être utilisée pour suivre l'évolution de la scoliose dans le temps ou pour juger de l'effet de certaines interventions (par exemple, physiothérapie, port de corset ou chirurgie) sur le déjettement du tronc. De plus, cette étude nous aidera à déterminer si d'autres facteurs tels que la douleur et le type ou l'importance de la scoliose peuvent être associés au déjettement du tronc.

INCONVÉNIENTS PERSONNELS ET RISQUES POUVANT DÉCOULER DE LA PARTICIPATION DE MON ENFANT

La participation de votre enfant à ce projet nécessitera de passer environ 90 minutes au CHU Sainte-Justine. Pour minimiser cet inconvénient, cette évaluation sera faite lors de votre visite à la clinique de scoliose. Il est entendu que la participation de votre enfant à ce projet ne fait courir, sur le plan médical, aucun risque que ce soit. Il est également entendu que sa participation n'aura aucun effet sur tout traitement médical auquel il serait éventuellement soumis.

CONFIDENTIALITÉ

Il est entendu que les observations effectuées en ce qui concerne mon enfant, dans le cadre du projet de recherche décrit ci-dessus, demeureront strictement confidentielles, à moins d'une autorisation de ma part ou d'une exception de la loi. Pour ce faire, un système de codification est en place au laboratoire de façon à identifier chaque sujet sans référer à son nom. Les dossiers sous étude seront conservés sous clé dans le local 1102A du CHU Sainte-Justine pour une durée de 10 ans.

Cependant, aux fins de vérifier le bon déroulement de la recherche et d'assurer votre protection, il est possible qu'un délégué du comité d'éthique de la recherche du CHU Sainte-Justine ou un représentant de l'organisme commanditaire consulte les données de recherche et le dossier médical de votre enfant.

Par ailleurs, les résultats et les images photographiques de cette recherche pourront être publiés ou communiqués dans un congrès scientifique mais aucune information pouvant identifier votre enfant ne sera alors dévoilée.

À des fins de protection, le Ministère de la santé et des services sociaux pourrait avoir accès à votre nom et prénom ainsi que ceux de votre enfant, ses coordonnées (adresse et numéro de téléphone), la date de début et de fin de sa participation au projet jusqu'à un an après de la fin de projet.

RESPONSABILITÉ DES CHERCHEURS

En signant ce formulaire de consentement, vous ne renoncez à aucun de vos droits prévus par la loi ni à ceux de votre enfant. De plus, vous ne libérez pas les investigateurs et le promoteur de leur responsabilité légale et professionnelle.

COMPENSATION FINANCIÈRE

Vous recevrez une somme forfaitaire de 25$ en compensation des frais encourus et des inconvénients subis.

CONFLITS D'INTÉRÊTS

Il est entendu que les responsables de ce projet de recherche ne sont nullement en conflit d'intérêt.

LIBERTÉ DE PARTICIPATION

La participation de votre enfant à ce projet de recherche est libre et volontaire. Vous pouvez retirer votre enfant de cette recherche en tout temps. Quelle que soit votre décision cela n'affectera pas la qualité des services de santé qui lui sont offerts.

EN CAS DE QUESTIONS OU DE DIFFICULTÉS, AVEC QUI PEUT-ON COMMUNIQUER?

Pour plus d'information concernant cette recherche, contactez la responsable de cette étude au CHU Sainte-Justine :
Carole Fortin, pht, candidate au doctorat au (514) 345-4931 poste 3277.

Vous pouvez également contacter la chercheure principale:

Mme Debbie Feldman au (514) 343-6111, poste 1252.

Pour tout renseignement sur vos droits à titre de participant à ce projet de recherche, vous pouvez contacter le Commissaire local aux plaintes et à la qualité des services du CHU Sainte-Justine au (514) 345-4749.

CONSENTEMENT ET ASSENTIMENT

Je déclare avoir lu et/ou compris les explications concernant la nature et le déroulement du projet de recherche. J'ai pris connaissance du formulaire de consentement et on m'en a remis un exemplaire. J'ai eu l'occasion de poser des questions auxquelles on a répondu à ma satisfaction. Après réflexion, j'accepte que mon enfant participe à ce projet de recherche. J'autorise l'équipe de recherche à consulter le dossier médical de mon enfant pour obtenir les informations pertinentes à ce projet.

____
Nom de l'enfant (lettres moulées)

____________________________________ ____________________
Assentiment de l'enfant (Signature) Date

Assentiment de l'enfant incapable de signer mais capable de comprendre la nature de ce projet : Oui ______ Non ______

____

Nom du parent, tuteur ou du participant de 18 ans et plus
(lettres moulées)

____ ____________________

Consentement du parent, du tuteur ou
du participant de 18 ans et plus (Signature) Date

J'ai expliqué au participant et/ou à son parent/tuteur tous les aspects pertinents de la recherche et j'ai répondu aux questions qu'ils m'ont posées. Je leur ai indiqué que la participation au projet de recherche est libre et volontaire et que la participation peut être cessée en tout temps.

________________________________ __________________________ ____________

Nom de la personne qui a obtenu
le consentement (Lettres moulées) Signature Date

Appendix C : Health Status Questionnaire

PROJET DE RECHERCHE

Fidélité et validité de la mesure clinique du déjettement du tronc auprès d'enfants et d'adolescents présentant une scoliose idiopathique.

RENSEIGNEMENTS PERSONNELS	
Numéro dossier de recherche :	
Date de naissance:	Âge:
Dominance:	Sexe:
Stature (cm):	Poids (Kg):
Habitudes de vie: École : ______; Travail occasionnel : _______Hres/sem, (Debout, Assis) Activités sportives :	

RENSEIGNEMENTS MÉDICAUX		
Type de scoliose:		
Angle de Cobb:	Apex:	Risser :

RÉSUMÉ DE DOSSIER

Histoire médicale :

____
____
____

Antécédents : ____
____

Conditions associées : ____
____

Examens (radiographies) : ____
____
____

Médication : ____

Traitement :

Surveillance _____
Corset ____ (type)_____________________________(port)_________ (hres/jr), jour____ nuit____
Physio RPG _____ Fréquence_____________ Correction inégalité des m. infs.______cm G D
Autre : ____

Date : ____________ Signature : ___________________________

Douleurs

Avez-vous des douleurs : Oui ☐ , Non ☐

Si oui,

Douleurs constantes______ , intermittentes______ hres/ jour (jour, soir, nuit)

occasionnelles _______ fois (sem,, mois)

Intensité : ______/ 10 ; À quel endroit : ____

Douleur en position : Assis ☐ = > < Debout ☐

Posture

Ce que vous pensez de votre posture

1. Ma posture est très bonne ☐
2. Ma posture est acceptable ☐
3. Ma posture est mauvaise ☐
4. Autre : Expliquez brièvement : ____

____

Date : ___________ Signature : __________________________

Trunk List Measurement :

Time 1 :

	1	2
Feet at 30°	_________ cm	_________ cm
Feet on gabarie	_________ cm	_________ cm

Time 2 :

	1	2
Feet at 30°	_________ cm	_________ cm
Feet on gabarie	_________ cm	_________ cm

Appendix D : SRS-22vf

Questionnaire du Patient
SRS-30 Adapté

Adapté de Haher, TR, et al SPINE, 24 :1435-40, 1999 et Asher, MA, et al, SPINE, 25 :2381-86, 2000. Utilisé avec autorisation.

À être complété par le PATIENT

Nom, prénom, initiale(s)
Numéro d'identification
Événement

Directives : Nous évaluons avec soin la condition de votre dos, et **il est important que vous répondiez à chacune des questions par vous-même**. Veuillez choisir **la meilleure réponse** à chacune des questions. Si vous devez changer une réponse, effacez complètement la réponse incorrecte et noicissez le bon cercle. Si vous n'êtes pas certain comment répondre à une question, s'il vous plaît, donnez la meilleure réponse selon vous.

Date (MM/JJ/AA) ☐☐ / ☐☐ / ☐☐

Noircir le cercle correspondant à votre réponse comme ceci : ●
Et non pas comme ceci : ⊠ ✓

S.V.P., ne pas écrire en dehors des cercles prévus à cet effet ou faire des traits sur le questionnaire

01. Choisissez l'expression décrivant le mieux l'intensité de la douleur que vous avez ressentie au cours des <u>six (6) derniers mois</u>.

- ○ Aucune
- ○ Légère
- ○ Modérée
- ○ Modérée à sévère
- ○ Sévère

02. Choisissez l'expression décrivant le mieux l'intensité de la douleur que vous avez ressentie au cours du <u>dernier mois.</u>

- ○ Aucune
- ○ Légère
- ○ Modérée
- ○ Modérée à sévère
- ○ Sévère

03. Au cours des <u>six (6) derniers mois</u>, avez-vous été une personne très nerveuse?

- ○ Jamais
- ○ Peu souvent
- ○ Parfois
- ○ La plupart du temps
- ○ Tout le temps

04. Si vous deviez passer le reste de vos jours avec l'aspect de votre dos tel qu'il est présentement, comment vous sentiriez-vous?

- ○ Très heureux
- ○ Un peu heureux
- ○ Ni heureux, ni malheureux
- ○ Un peu malheureux
- ○ Très malheureux

05. Actuellement, comment est votre niveau d'activité?

- ○ Alité
- ○ Inactif la majeure partie du temps
- ○ Travaux légers (tâches ménagères)
- ○ Sports et travaux manuels modérés (marche, bicyclette)
- ○ Activités normales sans restriction

06. Comment qualifiez-vous votre apparence lorsque habillé ?

- ○ Très bonne
- ○ Bonne
- ○ Passable
- ○ Mauvaise
- ○ Très mauvaise

07. Au cours des <u>six (6) derniers mois</u>, vous êtes-vous senti si déprimé que rien ne pouvait vous remonter le moral ?

- ○ Très souvent
- ○ Souvent
- ○ Parfois
- ○ Rarement
- ○ Jamais

08. Avez-vous de la douleur au dos lorsque vous êtes au repos?

- ○ Très souvent
- ○ Souvent
- ○ Parfois
- ○ Rarement
- ○ Jamais

09. Quel est votre niveau actuel d'activités à l'école/travail ?

- ○ 100% normal
- ○ 75% normal
- ○ 50% normal
- ○ 25% normal
- ○ 0% normal

10. Comment décririez-vous l'apparence de votre tronc, définie comme votre corps, à l'exception de la tête et des membres ?

- ○ Très bonne
- ○ Bonne
- ○ Passable
- ○ Mauvaise
- ○ Très mauvaise

11. a. Choisissez l'expression décrivant le mieux l'utilisation de médicaments pour votre dos *(Faire un seul choix).*

- ◯ Aucun
- ◯ Non-narcotiques chaque semaine ou moins (ex. aspirine, Tylenol, ibuprofen)
- ◯ Non-narcotiques chaque jour
- ◯ Narcotiques chaque semaine ou moins (ex. Empracet, Dilaudid, Percocet)
- ◯ Narcotique chaque jour
- ◯ Autre(s)

b. Si autre(s) médicament(s), veuillez spécifier.

____

____

c. Si autre(s) médicament(s), spécifiez l'utilisation.

- ◯ Chaque jour
- ◯ Chaque semaine ou moins

12. Votre dos limite-t-il votre capacité à faire des choses à la maison ?

- ◯ Jamais
- ◯ Rarement
- ◯ Parfois
- ◯ Souvent
- ◯ Très souvent

13. Au cours des <u>six (6) derniers mois</u>, vous êtes-vous senti calme et paisible ?

- ◯ Tout le temps
- ◯ La plupart du temps
- ◯ Parfois
- ◯ Peu souvent
- ◯ Jamais

14. Croyez-vous que la condition de votre dos affecte vos relations personnelles?

- ◯ Aucunement
- ◯ Légèrement
- ◯ Moyennement
- ◯ Modérément
- ◯ Sévèrement

15. Est-ce qu'un membre de votre famille ou vous-même avez des difficultés fiancières dûs à votre problème de dos?

- ◯ Sévèrement
- ◯ Modérément
- ◯ Moyennement
- ◯ Légèrement
- ◯ Aucunement

16. Au cours des <u>six (6) derniers mois</u>, vous êtes-vous déprimé ou découragé ?

- ◯ Jamais
- ◯ Rarement
- ◯ Parfois
- ◯ Souvent
- ◯ Très souvent

17. Au cours des <u>trois (3) derniers mois</u>, combien de jours vous êtes-vous absenté du travail ou de l'école pour un mal de dos?

- ◯ Aucun
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4 ou plus

18. La condition de votre dos limite-t-elle vos sorties avec vos amis et/ou votre famille ?

- ◯ Jamais
- ◯ Rarement
- ◯ Parfois
- ◯ Souvent
- ◯ Très souvent

19. Vous sentez-vous attirant pour une autre personne avec votre problème de dos actuel ?

- ◯ Oui, beaucoup
- ◯ Oui, assez
- ◯ Ni oui, ni non
- ◯ Non, pas beaucoup
- ◯ Non, pas du tout

20. Avez-vous été une personne heureuse au cours des <u>6 derniers mois</u> ?

- ◯ Jamais
- ◯ Peu souvent
- ◯ Parfois
- ◯ La plupart du temps
- ◯ Tout le temps

21. Êtes-vous satisfait des résultats de ce qui a été fait pour votre dos ?

- ◯ Très satisfait
- ◯ Satisfait
- ◯ Ni satisfait, ni insatisfait
- ◯ Insatisfait
- ◯ Très insastifait

22. Si vous aviez la même condition, accepteriez-vous la même façon de faire à nouveau ?

- ◯ Oui, définitivement
- ◯ Oui, probablement
- ◯ Pas certain
- ◯ Probablement pas
- ◯ Certainement pas

23. Sur une échelle de 1 à 9, 1 étant très bas et 9 étant très élevé, quel note donneriez-vous à l'image que vous avez de vous-même? (Encercle le chiffre approprié).

1 --- 2 --- 3 -- 4 --- 5 --- 6 --- 7 --- 8 --- 9
Bas **Élevé**

Les questions suivantes doivent être complétées seulement après le début du traitement pour votre problème de dos.

24. Par rapport à votre apparence d'avant traitement, comment vous trouvez-vous maintenant?

- ○ Bien mieux
- ○ Mieux
- ○ Identique
- ○ Moins bien
- ○ Beaucoup moins bien

25. Le traitement pour votre dos a-t-il modifié vos activités de tous les jours et votre façon de fonctionner ?

- ○ Augmenté
- ○ Inchangé
- ○ Diminué

26. Le traitement pour votre dos vous a-t-il changé votre capacité à profiter de vos sports/loisirs ?

- ○ Augmenté
- ○ Inchangé
- ○ Diminué

27. Est-ce que le traitement pour votre dos a ______________ votre mal de dos ?

- ○ Augmenté
- ○ Rien changé
- ○ Diminué

28. Est-ce que le traitement pour votre dos a changé votre confiance dans vos relations interpersonnelles ?

- ○ Augmenté
- ○ Inchangé
- ○ Diminué

29. Est-ce que le traitement pour votre dos a changé la façon dont les autres vous voient ?

- ○ Bien mieux
- ○ Mieux
- ○ Identique
- ○ Moins bien
- ○ Beaucoup moins bien

30. Est-ce que le traitement pour votre dos a changé l'image que vous avez de vous-mêmes ?

- ○ A augmenté
- ○ Inchangé
- ○ A diminué

Marquez au crayon sur les dessins les endroits où vous ressentez de la douleur. Si vous n'avez aucune douleur, n'écrivez rien et signez vos initiales.

Utilisez la légende ci-dessous pour indiquer le type de douleur que vous ressentez :

Légende **Picotements = 00000** **Coup de poignard = ////////**
Brûlures = XXXX **Douleur profonde = ZZZZ**