Posture in College Students: a quantitative analysis of the relationships between body alignment, physical fitness and lifestyle habits.

An independent study supported by Dawson College

by

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Abstract

The **purpose** of the study was to establish norms for alignment deficits and quantify how these deficits are influenced by fitness and daily habits. The **method** was as follows: 502 college students observed their body alignment, tested their fitness and identified lifestyle factors affecting their posture. Data was entered via cell phones into an excel sheet for analysis. This technology gave students a personal experience in evidence-based learning. The **results** confirmed that ideal posture is rare, only 18 students had neutral alignment. These students scored higher on fitness tests compared to students with deficits. Additionally, underweight and female participants had higher rates of deficits. The top three lifestyle factors were cell phone use, hand dominance and lack of sleep. The main **conclusions** are: 1. posture and fitness are codependent - students with good posture had better fitness results; 2. cell phone usage is creating a new techno-posture; 3. there are significant variations in body alignment and fitness according to gender, age and body weight.

Acknowledgements

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From its inception to competition, this study has taken several years of my attention. I am grateful to family and friends for their continued interest and support. I would like to thank physiotherapist Elizabeth Normand for her input, Gordon Hebert for his thoughtful editing, Dr. Elizabeth Brown for her critical thinking, and Roslyn Farmer for help with formatting and graphics, and finally, all my dance teachers, who gave me a lifetime interest in movement.

This study arose from a need to prepare a physical education course for Dawson College nursing students to help reduce their risk for back pain. Nurses spend their days lifting patients as they help them in and out of beds. Unlike lifting exercise weights, lifting human weight is riskier for the back; the weight is heavier and there can be unexpected shifts in movement. It is well documented that back pain is endemic to the profession and that it is a leading cause of absenteeism (Maul, 2003).

To prepare for the course, an extensive review of literature was conducted; unfortunately, there were many gaps in information, such as: a common understanding of the terms used to describe posture, the relationship of body alignment to fitness, and the significance of daily actions such as cell phone use to body alignment. It is hoped that the results of this study will advance the teaching of body alignment and fitness for all students.

The study was carried out using cellphone technology. Students entered their personal data via their phones through a web link to a Microsoft excel form, from which performance norms for body alignment were generated instantaneously and projected on a screen. This technology gave students a direct and personal experience in evidence-based learning and generated reliable results that reflected actual student performance.

The basic hypothesis of the study was that students can reduce the risk for muscular skeletal pain by improving their posture.

Perfect, neutral posture is rare (Bricot, 2008; Gokhale, 2008). Most people have at least one deficit; such as, forward head, flat back, knock knees, etc. Each alignment deficit reduces the efficiency of the muscular-skeletal system to support and mobilize the body. The research of neurologist Vladimir Janda laid the foundation for understanding how shifts in alignment affect the recruitment, length and tension of muscles, and reduce the range of motion (ROM) of joints

(Page, Frank, and Lardner, 1967). With good alignment, the skeleton provides an efficient framework to support the body's weight with only minimal muscle involvement; conversely, when the body is out of alignment, more muscles must be recruited to assist the bones in weight support. These muscles increase in tension and become resistant to being stretched. Additionally, when bones align efficiently, the joints between bones are optimally positioned for full mobility, and when bones join askew, the bones can rub against each other and are mechanically disadvantaged. Thus, each alignment deficit reduces movement potential.

To have good alignment means that one has no deficits: they stand tall, the body is symmetrical, and the shoulders are positioned squarely over the hips without rotation.

Research Questions and Objectives of the Study

The first objective of this study was to document the incidence of common alignment deficits in order to provide norms for students. Other than scoliosis (Mehlman, 2017) and flat feet (Bhoir, 2014), the rate of incidence for most deficits has not been established. Without norms, students have no reference for interpreting their results on alignment assessments.

The second objective was to investigate the relationships between alignment deficits. Stub your toe, and the chain reaction of compensatory shifts in weight can realign the body, all the way to the head.

The third objective was to quantify the relationship between fitness and body alignment. It takes strength to stand tall against gravity and thus one would expect that students with good alignment would have better results on tests of muscle strength such as push-ups. One would also expect that these students would have better scores on shoulder and hip joint mobility and would be in the normal category of body mass index (BMI). A study by Sung Min Son (2016) found a negative relationship between overweight and alignment; subjects with belly fat had increased lumbar lordosis and reduced balance.

The fourth objective was to quantify factors other than fitness that affect student posture. These can be considered in two groups: biological factors and lifestyle factors that students can modify.

The biological factors include growth and development, illness and injuries. Tall students tend to slump downwards; whereas, short students stretch upwards to be tall. Neuromuscular diseases such as muscular dystrophy, multiple sclerosis, spina bifida and cerebral palsy affect muscle development and alignment. Additionally, injuries to weight bearing joints can cause shifts in alignment.

The daily living factors can be divided into four categories: those that increase muscle weakness; those that increase muscle tension, and those that further the natural asymmetry of the body. And then there is the cell phone. It is in a category by itself, as it has its own unique posture and contributes to the negative effects of the other three.

A recent study by the World Health Organization cautions that 80% of children worldwide are too sedentary, and that one of the ill effects is muscle weakness. Most students spend their days sitting - at school and then at home playing video games (Garwood, 2019). Recent studies indicate that extended sitting has negative effects on body alignment, muscle development and health (Yaeger, 2013). Sitting upright is difficult for the body; within a short time, most students slump downwards into their chairs with a posterior pelvic tilt and forward pitched head and shoulders. Esther Gokhale (2008) believes that sitting and other sedentary activities are at the root of back pain. In cultures where people lead active lives, people stand tall and back pain not a concern.

In addition to extended sitting, students are not getting enough sleep. (Adams, 2013). Lack of sleep at night contributes to poor posture during the day, as the body slumps downwards seeking the rest it needs.

Frederick Alexander and Moshe Feldenkrais believed that posture was influenced by unconscious thoughts that create excess muscle tension and faulty movement patterns. As a young man, Alexander was an actor. His stage voice was often afflicted with hoarseness. Upon careful observation in a mirror, he noticed that when he used his stage voice, he altered the position of his head and his neck muscles became tense (Lynn, 2017). Thus, began his research into the connection between muscle tension, body alignment and movement. Moshe Feldenkrais (1972) followed a similar path.

We have learned from Hans Selye (1956) that stress can create excess muscle tension as the body prepares to fight or flee from a perceived threat. Many students report that their lives are stressful. Anxiety is one of the most common health issues students self-report on physical education medical forms.

Some of the most interesting literature on posture in relation to anxiety and tension has been written by musicians. Controlling stress is vital to performance, as muscle tension can prevent fluid movement of the hands, compromising musical expression (Werner, 1996).

In addition to stress, any activity that involves holding the body or repeated awkward movements can create excess muscle tension and joint strain (Kai, 2000; Cook, 2003).

The body has a natural asymmetry linked to hand and foot dominance that can affect posture. This one-sided preference determines on which shoulder we carry our bags and on which hip we carry our infants. For most people, this asymmetry is not significant. However, engaging in one-sided activities can further this imbalance to such an extent that it affects posture. Racquet ball players, artists who paint with one hand, and water polo athletes who favor one side when they skull, are examples of activities that can cause significant muscle imbalance between the two sides of the body.

The cell phone is a disrupter to posture (Sang, 2016; Twenge, 2017). The forward head texting position affects alignment of the whole body; the heavy head can pull the shoulder girdle forward putting the back into continuous tension and stiffness which can then alter pelvic tilt and the alignment of the lower body. Cell phone use also reinforces the asymmetry of the body as one texts and carries the phone with their dominant hand. The head-down texting position is so common that it has been given names: the iHunch; text neck and iPosture (Cuddy, 2015).

In addition to direct shifts in alignment, cell phone usage reinforces other factors that destabilize posture. Studies indicate that cell phone dependency is linked to sleep loss (Adams, 2013), as students have a compulsive desire to check messages well into the night. Constant cell phone use creates stress and anxiety as students strive to keep up with their friends on social media (Twenge, 2017). Additionally, cell phone posture has negative impacts on health; it reduces visual field and diminishes lung capacity. No one knows the long-term implications to health of having a generation with such poor posture at such an early age.

The final objective of the study was to investigate the link between alignment deficits and back pain. There is abundant research linking back pain to posture. (Page, 1967; Pavilack, 2016; McGill, 2008). According to Dr. Hamilton Hall (1980), 90% of people who suffer from back pain do so needlessly, as a result of poor posture. If Dr. Hall is correct, then students who have back pain have postural deficits. What sort of deficits? What percentage of students?

Posture Definition and Assessment

In college texts and fitness journals, the word posture is used interchangeably with body alignment. However, there is a difference between the two. Posture is a broad term, influenced by many factors. Posture is dynamic, continuously changing throughout the day. Body alignment is more specific; it is the measurable aspect of posture when the body is standing still.

Body alignment is often assessed from the singular perspective of the side view or sagittal plane (Gokhale, 2008; Starrett, 2013). From this view, one can observe the overall verticality of the body and the alignment of the head and pelvis relative to the vertical column. The head has been described as a ten-pound bowling ball sitting on a wobbly stick, and the pelvis as a swing that pulls on the bottom of the stick. With good alignment, the vertebral column has an elongated S shape, the head is balanced on top of the column and the pelvis sits on the bottom, neither swinging forward or backward.

From the frontal view, one can assess the right-left symmetry of the body. Posture in this plane is assessed by observing the evenness of the shoulders and hips. If one shoulder or hip is higher than the other, it can denote a bilateral difference in muscle development; which can exert torque on the body, leading to rotation.

From a bird eye view, one can look for rotation of the body in the transverse plane. Rotation of the shoulders and hips is determined if one side is more forward than the other. Rotation of the back is determined if one side of the rib cage appears higher than the other.

In most physical education texts, posture is synonymous with skeletal alignment and assessment is limited to the sagittal and frontal planes (Fahey, Insel, et al. 2017; Hopson, Donatelle, Littrell, 2013; Powers, Dodd, 2017). Posture is presented as a secondary, non-essential lab, separate from fitness. The exception is the Chevalier text (2016); in addition to body alignment, this posture assessment includes tests of abdominal muscle fitness and hip joint mobility. This text provides an important shift in the definition of posture, from simple body alignment, to an expanded concept that includes both muscle development and joint mobility.

The assessment in texts have some shortcomings. Alignment of the lower limb is often incomplete or omitted. The language to describe alignment is not consistent, ranging from simple descriptive words to medical terms. Additionally, the language can be judgmental with alignment described as “normal, good or poor”. In some texts, it is graded.

A review of assessments in fitness training texts yielded a more expanded concept of posture, one that fully recognizes the interdependence of muscle development, body alignment, joint mobility and body weight (Starrett, 2013; Cook, 2003; Kendell, 2005). Some athletic trainers include tests of proprioception, in particular, eye convergence (Gagne, 2015).

With regards to language, some trainers use a less judgmental vocabulary. Instead of describing posture as ‘normal’ they use the term ‘neutral’ (Starrett, 2013). The word ‘poor’ is often replaced by less pejorative terms, such as faults, deficits or imbalances.

Method

Participants

As physical education is compulsory in Quebec colleges, the student population is a cross-section of society, with many participants having physical and cognitive challenges. The selection of classes was random; it depended on the availability of teachers to schedule the assessment at a time when I was available. A total of 502 students participated.

Procedures

Ethics approval was granted from the Dawson College Research Ethics Board in the fall of 2019 and the study was carried out during the winter 2020 semester. Prior to participation, each student signed a consent form; participation was voluntary and anonymous.

The assessment was projected on a screen in the classroom. (see Appendix B). Following each test, students entered their results via their cell phones to a Microsoft excel form. Here is the short and long version of the link to the assessment.

Posture Study

https://forms.office.com/Pages/ResponsePage.aspx?id=emq2trv7uEKnxXEjQglO7z6WIN2kITtBrBPZdv64AoZUQkE4NkdRSzlWSVFJRzE2SjcwQUM0UTk1Vi4u

A Part – Body Alignment

With the aid of mirrors and a partner, simple observation was used to assess alignment in the three planes of the body: sagittal, frontal and transverse.

Sagittal Plane: Tests included: position of the head and shoulders, depth of the lumbar curve, pelvic tilt, and knee and elbow hyperextension. The pelvic tilt was a new test to eliminate false swayback (well-developed buttocks can give a false impression of swayback). Students placed their hands against their abdomen, palms on the hip bones, with fingers pointing downwards.

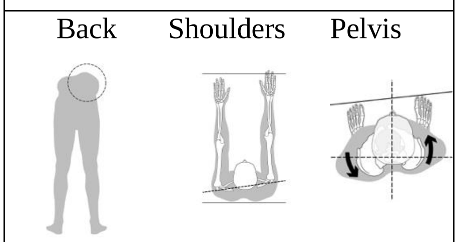
- hands that were vertical = a neutral pelvic tilt,
- hands that tilted inwards = an anterior tilt and
- hands that tilted outwards = a posterior tilt.

Frontal Plane: Tests included: head tilt; levelness of shoulders and hips; alignment of knees and ankles; and the depth of the foot arches.

Transverse Plane: Tests for shoulder and hip rotation were from Brico (2008) and Gagne (2015). The Adam's forward bend test was used for back rotation.

Figure 1

Transverse Plane Assessments



Note. Graphics by Nic DiLauro

B Part – Fitness Assessment

Tests of general muscle strength included standard push-ups, air squats, and planks. The hand dynamometer was used to test grip strength, and the one-foot test was used for balance. For the hand grip and balance tests, students recorded the difference in scores between the dominant and non-dominant sides. An eye-convergence test was also included.

C Part – Mobility, Cardiovascular Fitness and Body Weight

The toe touch test was used to measure general flexibility. The hip flexion test was used to assess hip mobility; students noted if there was a difference between the two hips. Two tests were used to assess shoulder mobility: the lying prone superman test, and the Apley scratch test to test for a difference in mobility between the two shoulders.

Due to time restrictions, cardiovascular fitness was not tested; students self-assessed their cardio fitness by selecting one of two categories: 1: My cardio is good; I can jog continuously for 20 minutes, or 2: My cardio needs improvement; I cannot jog for 20 minutes.

Students perception of body weight was assessed by selecting one of two categories: 1: My body weight does not affect mobility; 2: I have excess body weight that limits mobility.

Additionally, students entered their height and weight data to determine BMI.

D Part – Identification of Factors affecting Posture

The check list of factors included statements on sedentary living, cell phone use, stress, sleep, growth and development, injuries and illnesses, daily living movements that involve repetition or holding patterns, and use of dominant hand and foot in daily living.

Data Analysis

The study generated two types of data: categories and numeric values. The body alignment assessment was entirely based on categories, whereas the stability and mobility assessments were based on mostly numeric values. Mary Jorgensen, a researcher with the office Adaptech Research Network at Dawson College, carried out the following statistical analysis:

- Percentages were used to determine the incidence of body alignment deficits, the norms for fitness measures, and the order of significance of lifestyle factors. Additionally, percentages were used to determine variance according to gender, age and BMI.
- Chi-Square statistics were used to test for relationships between categorical variables.
- ANOVA analysis was used to test for relationships between body alignment categories and numeric scores on fitness tests.
- Correlation analysis was used to test for relationships between numeric fitness variables.

Results

Although a total of 502 students participated in the study, the number of students for individual assessments varied due to: late arrivals, cell phones losing power, student error, and injured students, unable to do certain tests. ***Only significant findings and relationships are presented***. The complete data analysis is available upon request.

Population Description

Gender. 1. males: 158; 2. females: 339; 3. prefer not to say: 3 (too low for a group)

Age. There were two age categories: **(**17 – 21): 459 students; (22+): 43 students

BMI. underweight: 52; neutral: 314; overweight: 97; obese: 31

Profile of students with neutral alignment for all tests

Only 18 students, or 4%, had neutral alignment for all tests. This elite group included:

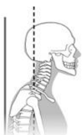
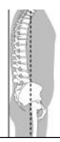
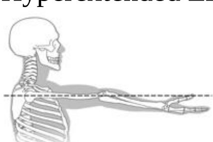
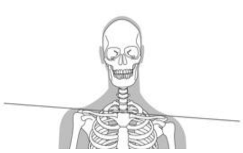
Gender. 10 female students and 8 male students.

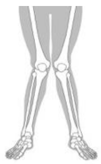
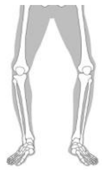
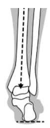
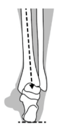
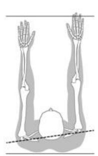
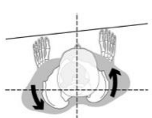
Age. Most were in the younger category: 16 vs. 2 in the older category.

BMI: normal: 14; overweight: 3 overweight; obese: 1

Body Alignment Results

Table 1
Results for Alignment Deficits

Alignment Deficits	%	**1. Population Variance by Age, Gender and BMI** **2. Relationships between Alignment Deficits** (p=.001)
		Sagittal Plane
Forward Head 	47%	1. Younger students presented forward head at 48% vs. 32% for older students.
Forward Shoulders 	37%	1. Underweight students presented forward shoulders at 46% vs. 36% for normal weight students. 2. Students with forward shoulders were likely to have forward head.
Swayback Flatback  	19% 8%	1. Underweight and overweight students presented swayback at 24% and 23% respectively vs. 14% for normal weight students.
Hyperextended Knees 	33%	1. Younger students presented knee hyperextension at 35% vs. 17% for older students. Female students had knee hyperextension at 38% vs. 24% for male students.
Hyperextended Elbows 	24%	1. Females students presented elbow hyperextension at 29% vs. 14% for male students.
		Frontal Plane
tilted head uneven shoulders 	22% 56%	2. Students with uneven shoulders were likely to have a tilted head.

uneven hips. 	25%	1. Underweight students presented uneven hips at 37% vs. 24% for normal weight students. 2. Students with uneven hips were likely to have uneven shoulders
Knock Knees   Bowlegs	20% 8%	
Ankle Pronation Ankle   Supination	30% 8%	1. Female students presented ankle pronation at 33% vs. 22% for male students.
Low Foot Arches High Foot Arches  	43% 8%	2. Students with ankle pronation were more likely to have low foot arches
Transverse Plane		
Shoulder Rotation 	45%	2. The rate of shoulder rotation was higher for students with uneven shoulders. The direction of rotation was most frequently towards the dominant hand side.
Pelvic Rotation 	47%	2. The rate of pelvic rotation was higher for students with uneven hips. The direction of rotation was most frequently towards the dominant foot side.
Back Rotation 	25%	1. Female students presented back rotation at 31% vs. 21% for male students. 2. If the shoulders are either uneven or rotated, there is a greater chance that the back will be rotated. If the pelvis is either uneven or rotated, there is a greater chance that the back will be rotated.

Fitness Results

The following results are presented: variance by gender and BMI (there was no difference between age categories); correlations between fitness variables; average scores in relation to standard scores, and where applicable, results in relation to dominant side.

Grip Strength. Male students had higher scores. Average scores were from 23-37 kilos in the dominant hand and from 21-34 in the non-dominant hand (similar to standard norms).

Grip strength in relation to hand dominance. Most students were stronger in their dominant hand: 70% vs. 18% for the non-dominant hand and 12% were equally strong. The average difference between hands was 2.75 kilos.

Correlation of grip strength to other measures. A moderate correlation was found between grip strength & push-ups and a weak correlation between grip strength & plank.

Push-ups. Male students had higher scores. Underweight and obese students scored in the poor category at 17% and 27% respectively compared to 8% of normal weight students. The average number of push-ups was 5-20, which was lower than many standard norms.

Correlation of push-ups to other measures. A moderate correlation was found between the number of push-ups and hand grip strength.

Planks. Females performed as well as males in 3 of 5 categories. Underweight and obese students scored in the poor category at 17% vs. 9% for normal weight students.

The average scores were between 1 and 2 minutes which was higher than some norms.

Air Squats. There were no gender differences in scores. The average number of squats was between 50 and 130, which was higher than many standard norms.

Correlation of number of squats to other measures. A weak correlation was identified between number of squats and one-foot balance.

One-Foot Balance. There were no gender or BMI differences in scores.

Balance scores in relation to foot dominance. The average time for the dominant foot was from 15 – 60 seconds, compared to the non-dominant foot: 10 – 45 seconds.

Correlations of one-foot balance to other measures. Weak correlations were found between balance and squats, push-ups and planks.

Toe Touch Flexibility. Females students scored higher than male students. Male students scored in the below average category at 37% vs. 22% for female students.

Hip Joint Range of Motion. Females scored higher than males for both hip joints. Male students scored in the poor category at 45% vs. 28% for female students.

Hip joint ROM in relation to foot dominance. 87% of students had equal hip ROM.

Relationships between toe touch flexibility and hip joint ROM. A significant relationship was found between these two measures.

Shoulder Joint Range of Motion.

Shoulder joint ROM in relation to hand dominance. Most students had a greater ROM in the shoulder of the non-dominant hand: 47% vs. 15% for the shoulder of the dominant hand; 38% had equal ROM.

Cardiovascular Fitness. Female students scored in the poor category at 53% vs. 38% for male Students. Obese, overweight or underweight students scored in the poor category at category at 67%, 54% and 56% respectively, vs. 44% for normal weight students.

Relationships Between Body Alignment and Fitness

Students with Neutral Alignment

The 18 students with neutral alignment had higher scores for tests of muscle strength

- for the hand grip test, these students registered an additional kilogram (Figure 2).

- students in this group performed an average of 30 more air squats (Figure 3)
- male students in this group performed an average of 5 more push-ups (Figure 4)
- male students held the plank for an average of 36 more seconds; female students held the plank for an average of 8 more seconds (Figure 5)

BMI. 77% of students with neutral alignment were in the normal BMI category vs. 62% for the general population.

Mobility. The 18 students were among those that did well on mobility tests. Students with alignment deficits had lower scores on these measures. Additionally, one can assume that the 18 students had good hip mobility because they performed more squats than other students, and squat performance correlated with hip mobility (Figure 6).

Students with Alignment Deficits

The majority of students (96%) had at least one alignment deficit. Although many of these students scored in the excellent category for fitness; the majority were average. A few relationships were identified between specific alignment deficits and fitness scores:

- Students with either flatback or swayback had lower scores for plank (Figure 7).
- Students with flat back had lower scores on the toe touch test; 40% of these students were in the below average category vs. 22% for students with a neutral lumbar curve.
- Students with forward shoulders had lower scores for shoulder mobility. On the Superman test, students with forward shoulders were in the below average category at 56% vs. 44% for students with neutral shoulder alignment.

Table *Student Identification of Factors Affecting Posture*		
%	**Factor**	**Population Variance by Age, Gender and BMI**
77%	Cell Phone use	
72%	Use of dominant hand	
67%	Inadequate sleep	
67%	Sitting	• Female students reported sitting at 70% vs. 58% for males. • Younger students reported sitting at 66% vs. 58% for older students. • Obese students reported sitting at 84% vs. 63% for normal weight students.
54%	Stress	
50%	Growth & Development: being tall 22%; flat feet – 20%; poor diet – 8%; scoliosis 5%; uneven legs – 5%; childhood labour – 1%; pectus - .04%	• Male students reported tallness at 33% vs. 17% for females and underweight students reported tallness at 31% vs. 19% for normal weight students. • Underweight students reported scoliosis at 15% vs. 5% for normal weight students. • Female students reported scoliosis 8% vs. 2% for male students.
42%	Holding positions & repetitive actions	• Female students reported holding positions at 45% vs. 34% for male students.
42%	Use of dominant foot	
34%	Joint Instability from activity: hyperextended knees from dance: 12% weak ankles from ski and skateboots:11% toe deformity from ballet: 4%; swayback from gymnastics: 3%	• Females students reported hyperextended knees at 17% vs. 5% for male students. • Younger students reported hyperextended knees at 14% vs. 7% for older students, and weak ankles from ski / skate boots at 12% vs. 5% for older st. • Underweight students reported scoliosis at 15% vs. 5% for normal weight students.
26%	Joint instability from injury: knee: 27%; ankle: 26%; back: 15%; shoulder: 13%; hip: 5%; elbow: 5%	
14% 10%	Physical health Anxiety and Depression	• Underweight students reported a health condition at 23% vs. 15% for normal weight students. • Female students reported anxiety and depression at 12% vs. 5% for male students.

Discussion

Limitations of the Study

The data for the body alignment assessment was based on observation, not measurement, and was entered by the students via their cell phones, without verification. With regard to the fitness assessment, it was difficult to regulate student performance in a group setting.

New discoveries on the relationship between body alignment and fitness

An important insight from this study is the connection between muscle fitness and body alignment. The finding that students with neutral alignment had better fitness results is evidence that body alignment and fitness are codependent. General muscle strength provides support to the upper body so that it resists gravity and remains upright; it gives stability to the shoulders and hips to prevent rotation; it maintains resting muscle length and tension so that the body is balanced and symmetrical, and it aligns the bones efficiently so that the joints have full range of motion, all of which optimizes movement potential, yielding higher scores on fitness tests.

Variations in Results Relative to Age, Body Weight and Gender

Body Weight. If it is clear from the results that well developed muscles support good posture, it is also clear that inadequate muscle development renders the body vulnerable to gravity, resulting in alignment faults. In the adult world, underweight is often considered to be desirable and it is associated with slimness. For 18 yr.-old students, underweight is linked to lack of muscle development. Compared to other BMI categories, underweight students had higher incidences of forward head, forward shoulders and anterior pelvic tilt. These students had lower scores for push-ups planks, and reported lower cardiovascular fitness compared to students in the normal BMI category. Additionally, underweight students reported scoliosis at 15% vs.

5% for the general population. This important finding suggests that being underweight can be considered a warning sign for scoliosis.

By comparison, obese students had the same rates of alignment deficits as normal weight students. However, they had similar scores as underweight students on tests of muscle fitness - lower scores for push-ups, planks and reported lower cardiovascular fitness. If one compares the results of the two groups, it appears that underweight students are more disadvantaged than obese students. At 10% of the population, there are more underweight students than obese students at 6%, yet underweight is generally not considered as serious a health issue.

Recently, there has been a movement in Quebec to minimize the inclusion of body weight as a component of physical fitness. The findings of this study indicate that obesity and underweight are serious deterrents to health and should be included in the curriculum.

Age. Older students had lower rates of knee hyperextension and forward head compared to younger students. The lower rate of knee hyperextension might be explained by a reduced participation in artistic sports, and the lower rate of forward head could be linked to a lower dependency on cell phones. There were no differences between the two age groups for tests of muscle strength or cardiovascular fitness; and only one difference for a test of mobility, older students had reduced hip mobility at 50% vs. 32% for younger students.

Gender. The results of the body alignment assessment revealed that female students are more disadvantaged than males. Female students had a higher incidence of back rotation, knee and elbow hyperextension and ankle pronation, and reported a higher incidence of scoliosis. This unexpected gender difference in alignment is poorly understood.

Surprisingly, female students had better results than expected on some muscle fitness tests. They performed as well as males in 3 of 5 categories of plank, and for all 5 categories of air squats and balance. These findings defy gender-based fitness norms.

The finding that females rated their cardiovascular fitness as needing improvement 15% more frequently than males, suggests that females have poorer cardio health.

Impact of Dominant Side to Body Alignment and Fitness.

The next results are evidence of the impact of hand dominance on alignment and fitness:

- 70% of students were stronger in their dominant hand by an average of 2.75 kilos. This result suggests that the dominant hand becomes stronger with more frequent use. Hand grip strength is an indicator of arm and shoulder strength. For many actions such as opening a heavy door, it is not just the hand that is active, but the entire side of the body.
- 45% of students reported rotation through their shoulder girdle; the direction of rotation was most often towards the dominant hand. This result suggests that the muscle imbalance due to repeated actions with the dominant hand leads to rotation of the shoulder girdle.
- 47% of students had greater mobility in the shoulder of the non-dominant hand; 38% had equal mobility, and only 15% had greater mobility in the shoulder of the dominant hand. This unexpected finding suggests that stressful actions by the dominant hand may lead to mobility loss of the shoulder. Additionally, the mobility loss may be due to forward rotation of the dominant shoulder.
- 56% of students have one shoulder higher than the other; however unexpectedly, the shoulder of the non-dominant hand was just as likely to be the higher

shoulder. This finding is more difficult to interpret. Perhaps the higher shoulder is determined by carrying preference, and some people prefer to carry on the shoulder on the non-dominant side, to free the dominant hand to do tasks.

These results suggest that hand dominance is a primary source of asymmetry for the upper body, resulting in significant muscle imbalance and loss of shoulder mobility.

Consider the results related to lower limb dominance: 47% of students reported rotation of the pelvic girdle; the direction of rotation was most often towards the dominant side. It is well known that uneven length limbs lead to pelvic rotation; when standing, the muscles of the shorter limb support more weight, consequently, these muscles become stronger and exert torque on the pelvis. However, the results suggest that use of the dominant limb in daily living may be as important a factor; only 25% of students reported having uneven length limbs, as identified by having uneven hips, yet another 22% had hip rotation. For these students, hip rotation must be due to a preference for using one side: always pushing off with the same foot, shifting the body weight onto one foot when standing, or carrying infants on one hip. Unlike the shoulder joints, the rotation of the pelvis did not create a difference in ROM of the hip joints, which is expected, considering that the hip joint is a larger, deeper, more stable joint compared to the shoulder.

Importance of testing Alignment in the Transverse Plane

Having one shoulder or hip higher than the other may seem like a benign deficit; however, the results of this study indicate that this unevenness can lead to rotation of the body, which is observable in the transverse plane. The vertebral column is the central structure of the body connecting the shoulders to the pelvis. Any rotation through the shoulders or pelvis can exert torque on the vertebral column, straining intervertebral structures and muscles, increasing the risk for back pain. Thus, it is hoped that testing in the transverse plane will become part of standard alignment assessments. Additionally, it is hoped that the understanding of neutral posture will include the idea of squaring the shoulders over the hips, in addition to the concepts of standing tall and being symmetrical.

Advantage of Cell Phone Technology to Generate Reliable Fitness Norms

There were many differences in the fitness norms of this study compared to norms in texts. Not only did female students do as well as males on a few tests of general muscle strength, the average scores for plank, push-up, and air squats were significantly different from standard norms. These differences can be attributed to the distinct performance criteria set by the evaluator, and class size. For example, the results for push-ups can vary greatly according to the position of the hands and depth of the push-up. Additionally, in a class of 25 students, it is more difficult to ensure adherence to performance criteria, compared to a testing situation with a few students. Whereas the norms in textbooks may not be representative of student performance, the norms generated using student cell phone technology are reliable. It was an easy task for the statistician, Mary Jorgensen, to generate fitness norms from the data sheet. Additionally, it was interesting for students to have a direct experience with data collection and statistics.

Alignment deficits of the typical student and their significance to movement potential

If one considers the alignment deficits that are close to the 50% rate, then one could describe the typical college student as follows: they have one shoulder higher than the other, their head is permanently forward and they are rotated through their shoulder girdle and pelvis. Additionally, the typical student would possibly have ankle pronation; it was reported at 43%.

Compared to a student with neutral alignment, one would expect that the typical student would have lower fitness results; the changes to muscle length and tension associated with alignment deficits would result in earlier muscle fatigue and reduced joint mobility. The following results support this analysis: students with flatback or swayback, held the plank for less time than students with a neutral lumber curve; students with flat back had lower results on toe touch flexibility, and students with forward shoulders had reduced shoulder mobility.

The combination of alignment deficits would disadvantage the typical student for skill development. In addition to early muscle fatigue, the forward head position would reduce visual field, the rotation through the shoulder and pelvic girdles would create an inefficient gait, and ankle pronation would destabilize the body.

The emergence of techno-posture

Students identified cell phone usage as the number one factor affecting their posture. The finding that 47% of students have forward head is a testament to the effects of cell phone use. In the past, forward head was associated with older adults, thus one could say that cell phone use is aging students. After cell phone use at 77%, students identified hand dominance at 72%; sitting and lack of sleep at 67%, and stress at 54%. It is interesting to consider the connection of cell phone usage to these other factors. Cell phone usage reinforces the negative effects of hand dominance; it is a sedentary activity that increases sitting time; it reduces sleep as students' text late at night and adds to anxiety for those who suffer from cell phone addiction.

Consequence of techno-posture and other alignment deficits

Students responded to the question: 'If you have muscular-skeletal pain, would you attribute it to posture imbalance?' Only 27% of students indicated they were pain free; 31% said "yes" that posture imbalance was linked to pain and 34% said "maybe".

The long-term prognosis of body alignment deficits is not good. Left unacknowledged, minor imbalances can progress, leading the body into a downward spiral of muscle weakness and tightness, joint instability, decreased mobility and discomfort.

Importance of Body Alignment Assessment and Posture Education

There are many great athletes with alignment deficits. Usain Bolt, the fastest sprinter of all time, has scoliosis and an uneven gait (Longman, 2017). It is not the deficit that is the problem, it is not knowing about it and not having the knowledge to fix it. Many students were surprised to learn that they had alignment faults. Without the careful observation of assessment, most alignment deficits would be unnoticed. As for many aspects of health, overcoming a concern is easier when it is small. Ideally, it would be beneficial for students to have a dedicated posture course in secondary school. However, discussion of the effects of technology use, or posture breaks – a one-minute stretch or push-up challenge, would be a welcome addition for any classroom. What we have learned from this study, is that most alignment deficits can be overcome with muscle development combined with awareness of body alignment in daily living.

Conclusions

The finding that 96% of students have at least one alignment deficit leads to the conclusion that there is no 'normal' body alignment, everyone has something. This is an important message for students who may feel that their bodies are less than perfect.

The high incidence of rotation of the shoulders, hips and back underscores the importance of testing body alignment in the transverse plane and suggests that the definition of neutral body alignment should be expanded to include the idea of squaring the shoulder and hips.

The results of the study provide conclusive evidence that body alignment and fitness are correlated. The few students with neutral alignment had better scores on fitness tests. It is recommended that further investigation be carried out to understand why underweight and female students had higher rates of alignment deficits.

Students identified cell phone usage as the most significant factor affecting their posture, followed by hand dominance. Many results for body alignment and fitness were linked to these factors. Additionally, cell phone usage was linked to other lifestyle factors that inhibit posture such as lack of sleep, sitting and stress. One can conclude that cell phone culture is a major disruptor to posture.

What Does this Article Add to Physical Education?

This article offers a new way of thinking about body alignment in relation to fitness. Teaching fitness from a body alignment perspective should increase the efficiency of exercise, help students overcome alignment deficits and reduce the risk for back pain.

The study offers a new method for creating student activity norms by having students enter their data using their phones to an excel sheet. Compared to norms in fitness texts, the norms generated in this manner are more representative of actual student performance.

The posture assessment developed for this study is an improvement over what is currently available in college physical education texts. It is comprehensive; it provides a measurable definition of neutral body alignment; it is the first to test alignment in the transverse plane; it offers a non-judgmental vocabulary for discussing posture. It should prove to be an essential tool for teachers to demonstrate the links between body alignment, fitness and lifestyle behaviors.

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Appendix A

Figures

Figure 2

Grip Strength by Alignment and Gender

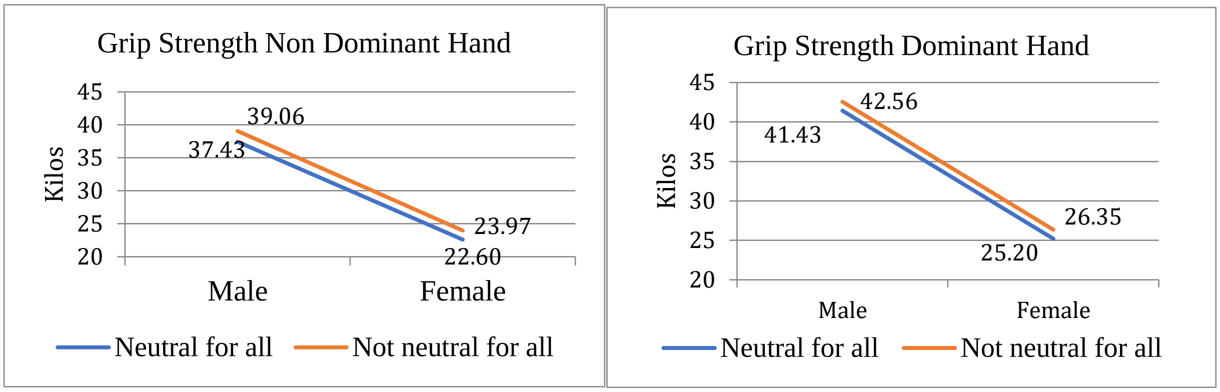


Figure 3

Squats by Alignment

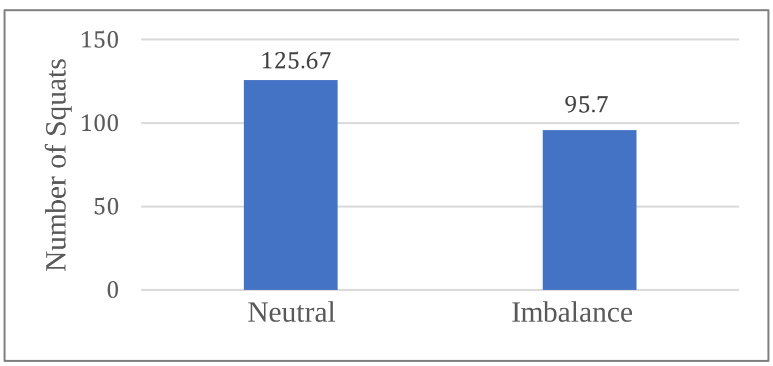


Figure 4

Push-ups by Alignment and Gender

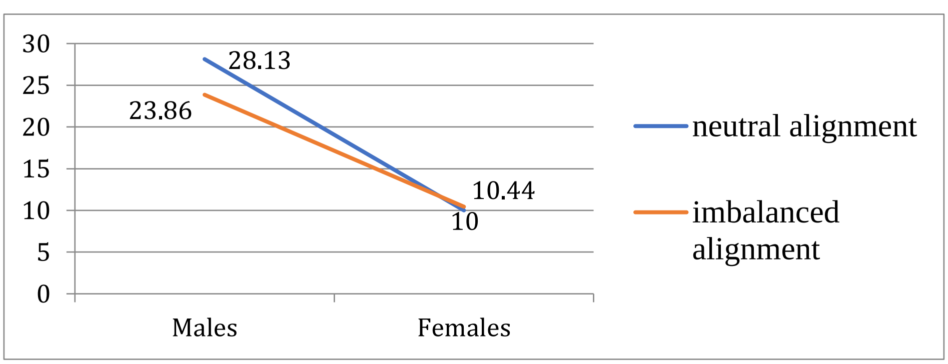


Figure 5

Plank Time by Alignment and Gender

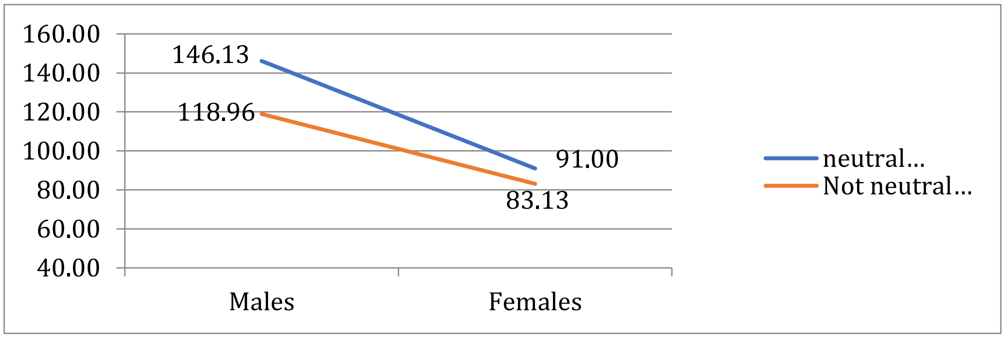


Figure 6

Relationship between Squat Performance and Hip Mobility

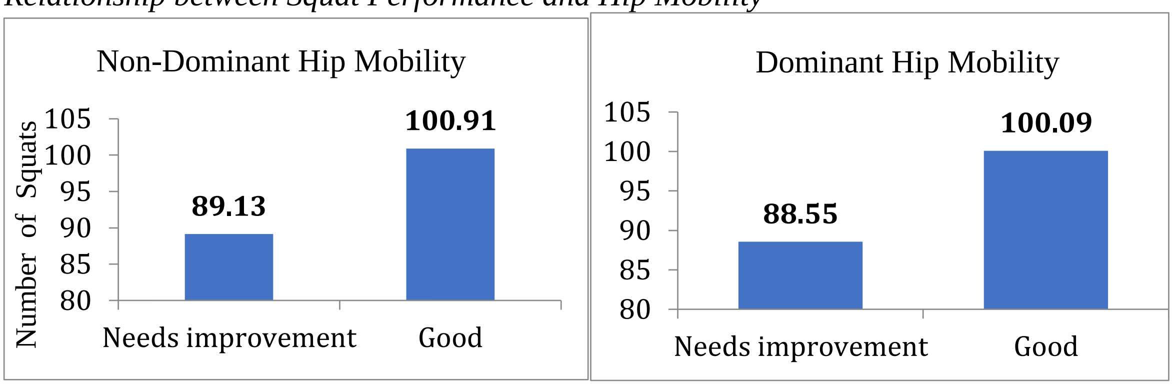
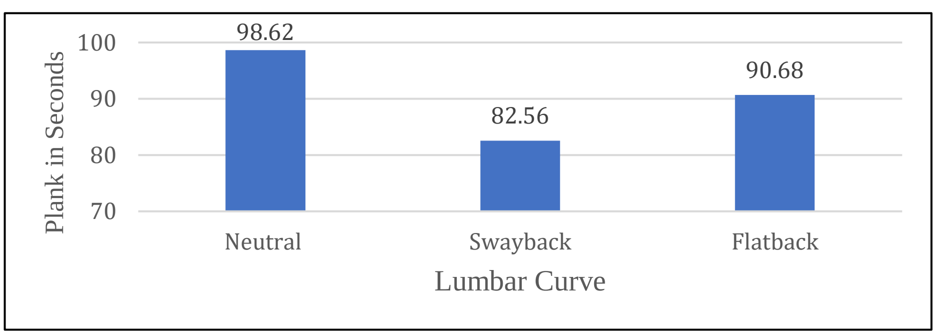


Figure 7

Plank Time by Lumbar Curve



Appendix B

Dawson College Posture Study

We tend to think of posture as skeletal alignment. However, without muscles to support the bones, we would have one posture – horizontal. Thus, posture is as much about muscles as it is about bones. Posture is also about joints. With neutral posture, the bones join together in the most efficient manner allowing for full mobility. For this study, assessments include:

A. body alignment

B. stability – planks, push-ups, air squats, grip strength and one-foot balance

C. mobility – toe touch, hip and shoulder joint Range of Motion (ROM), cardiovascular fitness

D. identification of factors in daily living that affect posture.

For the body alignment assessment, please stand normally – do not pull yourself up! For many tests, you will be asked to identify your dominant and non-dominant side.

Body Alignment

Body alignment is assessed through observation in three planes: sagittal, frontal and transverse. With neutral posture, the body is vertical, symmetrical and square.

The **vertical** component is assessed in the **sagittal plane**.

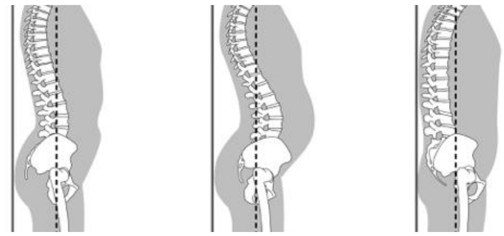
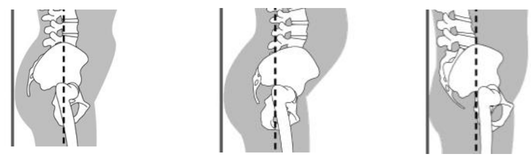
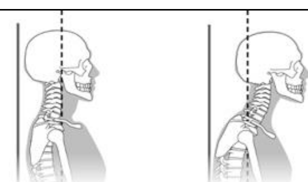
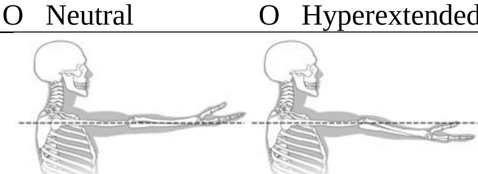
The **symmetrical** component is assessed in the **frontal plane** – how level are your shoulders & hips?

The **squareness** of your shoulders, hips and back is assessed in the **transverse plane** from a bird's eye view.

Graphics by Roslyn Farmer

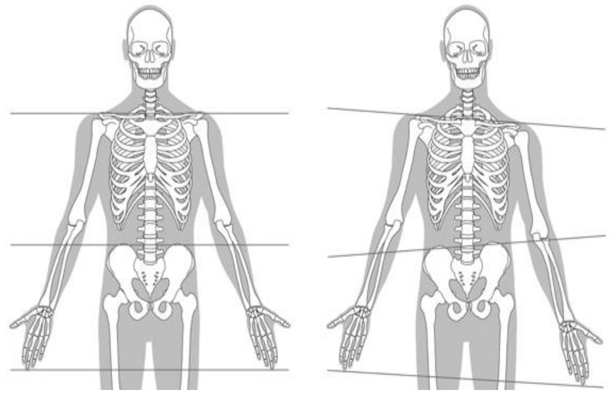
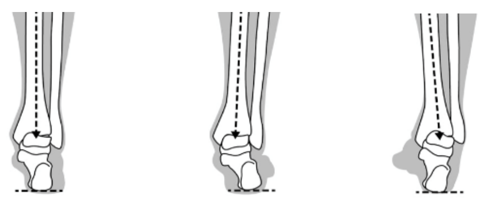
Body Alignment Assessment

Sagittal Plane – Vertical Component

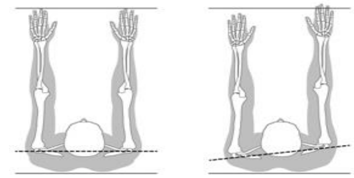
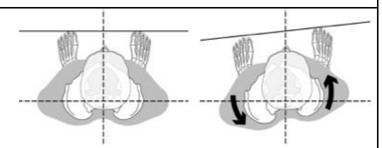
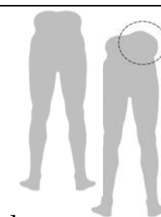
Lumbar Curve: wall test Stand with your buttocks and upper back touching a wall, slide your hand into the space between the wall and your lower back. Your lumbar curve is: neutral: the hand fills the space Swayback: the forearm fills the space, you have flat back: only a finger can slide in	 O Neutral O Swayback O Flat back
Pelvic Tilt: Hands on Belly Test Put your hands on your belly – palms on hip bones and fingers pointing down towards the pubic bone. neutral pelvic tilt = hand vertical anterior pelvic tilt = fingers angle inwards posterior pelvic tilt = fingers angle outwards	 O Neutral O Anterior O Posterior
Head Have your partner observe the ear relative to the shoulders. Neutral head = ear over shoulders Forward head = ear in front of shoulders	 O Neutral O Forward
Shoulders Have your partner observe the shoulders Neutral: shoulders are sideways; upper back is flat Forward: shoulders are forward & upper back is rounded forward	 O Neutral O Forward
Knees Observe your knees in the mirror. Neutral: the kneecap appears as a bump; the calf & thigh are aligned Hyperextended: the kneecap lies flat and the calf appears behind the thigh	 O Neutral O Hyperextended
Elbows Extend your arms. The elbow joint is: Neutral: the elbow joint = 180˚ Hyperextended: the elbow joint is greater than 180˚	 O Neutral O Hyperextended

Graphics by Nic DiLauro

Frontal Plane – Side to Side Symmetry

Head – viewed from the front Neutral: ears are level Tilted: one ear is higher than the other **Shoulders** – viewed from behind Neutral: shoulders are level Uneven: one shoulder is higher **Hips** – viewed from behind. Place your hands on your hips with thumbs facing backwards and fingers facing forwards Neutral: thumbs are even Uneven: one thumb is higher	 Head O Neutral O tilted Shoulders O Neutral O uneven Hips O Neutral O uneven
Knees Neutral: legs are straight Knock knees: knees roll inwards Bowlegs: knees roll outwards	 O Neutral O Knock Knees O Bowlegs
Ankles Neutral: achilles tendon is straight; ankle bones appear equally prominent Pronated: achilles tendon curves inwards; inside ankle bone is prominent Supinated: achilles tendon curves outwards; outside ankle bone is prominent	 O Neutral O Pronated O Supinated
Foot Arches From a standing position, bend over and slide a finger under the inside border of each foot. Neutral: finger slides in 1 inch Low: finger barely slides in or not at all High: finger slides in more than an inch	 O Neutral O Low O High

Transverse Plane – Square vs. Rotation

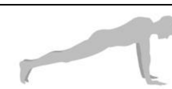
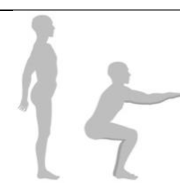
Shoulder Gridle Sit square on a bench, close your eyes, then reach your arms forward. Have your partner determine if your shoulder girdle is: Neutral: fingertips reach the same distance Rotated to dom. side: fingers of dom. hand reach further Rotated to n-dom. side: fingers of n.-dom. hand reach further	 O neutral O rotated to dominant hand O rotated to non-dom. hand
Pelvic Girdle Stand with your toes touching a horizontal line. Close your eyes, shake your feet and reposition them. Look down at your toes. Are they still aligned, or do the toes of one foot reach further? Neutral: the toes align horizontally Rotated to dom. side: toes of dom. foot reach further Rotated to n.-dom. side: toes of n.-dom. foot reach further	 O neutral O rotated to dominant foot O rotated to non-dom. foot
Back Tuck your chin in, bend forward with a rounded back. Have your partner observe the symmetry of the rib cage. Your back is: Neutral: the two sides of the rib cage are equal Rotated to dom. side: rib cage is lower on dom. side Rotated to n.- dom. side: rib cage is lower on n.-dom. side	 O neutral O rotated to dom. hand O rotated to non-dom. hand

Mobility Assessment

16. Shoulder Girdle Mobility Lie on your stomach. Keeping your chin on the mat, lift your arms forward like superman. Your shoulder girdle mobility is: average: arms at ears below average: arms below ears above average: arms above ears	 O average O below average O above average
17. Comparison of Shoulder Joint Range of Motion Place the back of the dom. hand on the back and move it upwards to the shoulder blades. Repeat with the non-dominant hand. Does one hand reach further upwards than the other? Equal: the fingers reach the same height Shoulder of dom. hand has > ROM: fingers reach further Shoulder of n.-dom. hand has > ROM: fingers reach further	 O equal ROM O shoulder of dom. hand > ROM O shoulder of n-dom. hand > ROM

Toe Touch Flexibility From a standing position, reach down and touch your toes. Your flexibility is: Average: fingers touch your toes Below average: fingers reach the ankles Above average: knuckles reach the floor	O average O below average O above average 
Hip Joint Range of Motion Lying on your back with legs straight, keeping your hips in contact with the mat, raise one leg and then the other. Good: legs lift to about 90˚ Deficient: angle is < 90˚ **Comparison of Hip Joint Range of Motion** Repeat the above exercise, noting if there is a difference between the dom. and n-dom. side. Equal: legs lift to same height Hip of dominant foot > ROM: leg lifts higher hip of n-dominant foot > ROM: leg lifts higher	 O good O deficient O equal ROM O hip of dom. foot > ROM O hip of n.-dom. foot > ROM

Stability Assessment

The Plank Count the number of seconds you can hold a plank. (teacher counts time in 5 second intervals)	 time _____ sec.
Standard Push-ups Count the number of push-ups you can complete with fingers pointing forwards and chest descending until elbows flex to 90˚	number _____ 
Air Squats Count the number of squats you can perform to chair height. (teacher sets tempo – 2 second count for each)	number _____ 
Grip Strength Squeeze the hand grip dynamometer with each hand.	dom. hand. _____ kilos n-dom. hand _____ kilos
One-foot Balance with eyes closed Count how many seconds you can balance on each foot. Place the toes of one foot on top of the supporting foot. (teacher counts time in 5 second intervals)	dom. foot _____ sec. n-dom. foot _____ sec.