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# The concurrent and predictive validity of a tool to measure strength engagement during inclusive equestrian vaulting

**Virginia Lefeaux[1], Lynneth Stuart-Hill[1], Helgi Sangret[2], Dani Vipond[2], Amber Nordquist[1], Robert Busch[1], and Viviene Temple[1]**

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**Abstract:** Participation in muscle strengthening activities is a less examined component of public health physical activity guidelines for children and youth compared to participation in physical activity. In part, the lack of focus on strength is associated with the difficultly of measuring strength activities during participation. The aim of this pilot study was to develop and provide evidence of the concurrent and predictive validity of the Strength Observation during Vaulting (SOV) tool. Six female youth (4 with a disability and 2 without a disability) ranging in age from 11 – 22 years ($M_{age}$ = 14.2 y, SD = 4.0) participating in a 5-day inclusive equestrian vaulting camp were recruited. Participants completed three measures of strength, and video of vaulters engaging in camp activities was coded using the System for Observing Fitness Instruction Time (SOFIT) and SOV tools. From a linear regression model (significant p = .020), the three measures of strength accounted for 98.7% of the shared variance with time spent in SOV levels 4 and 5. Bivariate correlation coefficients comparing SOV levels 4 and 5 and moderate-vigorous physical activity (MVPA) from SOFIT were r = .73 for all contexts, r = .89 for floor-work, r = .64 for barrel vaulting, r = .76 for horse vaulting, and r = .81 for stable chores. The predictive and concurrent validity of the SOV tool was more than adequate. Based on these results, the systematic observation is a feasible approach to assess engagement in strength activities during vaulting.

**Keywords:** disability; sedentary behaviour; moderate-to-vigorous physical activity; youth; observation; equine

## Introduction

Acrobatics on horses dates back to Roman times, but modern equestrian vaulting was developed in post-war Germany to introduce children to equestrian activities (Smith, 2014). Today, equestrian vaulting is open to all ages and abilities (Equestrian Canada, 2020) and it involves the integration of gymnastics and dance movements on a horse wearing a surcingle with handles. The horse moves at a walk, trot, or canter in a circular motion while attached to a lunge line. Vaulters may work alone on the horse or may be joined by a partner or teammates for group performances (Equestrian Canada, 2020).

The sport of equestrian vaulting includes learning individual moves and then linking moves together to form routines that may be completed or performed on the horse. Basic vaulting moves include mounting, holding static positions, dynamically transitioning from move to move, and dismounting (Equestrian Canada, 2020). Vaulters should also be comfortable performing a "bailout" from the horse if they were to fall (Temple et al., 2019). Vaulters typically practice moves on a stationary barrel that mimics the height and shape of the horse, prior to attempting them on the horse (Temple et al., 2019). Working on the barrel allows for the safe progression of skills (Smith, 2014). Vaulters may also practice skills and progressions on mats, trampolines, and other stationary equipment (Equestrian Canada, 2020).

Once vaulters are comfortable with each move, they begin to piece them together to create a routine set to music (Equestrian Canada, 2020). In competitive vaulting, vaulters may perform a compulsory, freestyle, or team routine comprised of static and dynamic elements (Equestrian Canada, 2020). The ability to perform and eventually link vaulting elements requires strength to ensure fluidity and control.

## Importance of Strength

The World Health Organization (WHO) guidelines on physical activity and sedentary behaviour state that children and youth aged 5-17 years should accumulate on average at least 60 minutes of moderate-to-vigorous physical activity each day, and include muscle and bone-strengthening activities at least three days per week (World Health Organization, 2020). A muscle-strengthening activity increases skeletal muscle mass, while a bone-strengthening activity produces load on the bones helping to promote bone strength (World Health Organization, 2020). Improving muscular strength helps to increase bone density in children (Smith et al., 2014; Tan et al., 2014) thereby lowering the risk of fragility fractures in adulthood (Tveit et al., 2015). Smith and colleagues' (2014) systematic review of the benefits of muscular fitness for children and adolescents also demonstrated a negative relationship between muscular strength and central and total adiposity in children, and positive relationships muscular strength and self-esteem and perceived sports competence. Additionally, strength in the core muscles is important for controlling fine-motor skills, as the core musculature supports peripheral joints that are needed for activities of daily living such as tying shoelaces, brushing teeth, and buttoning clothes (Merino-Andrés et al., 2022).

Children and youth with disabilities generally have a lower level of strength and physical fitness, when compared to their peers without disabilities (Bakker et al., 2002; Blomqvist et al., 2013; Emck et al., 2011; Pan, 2014; Tsai et al., 2017). For example, Emck and colleauges (2011) found that 9 – 11 year-old children with mental disorders (emotional, behavioural, and pervasive developmental disorders) had lower levels of cardiorespiratory fitness and muscular strength than normative samples as assessed on the Motor Performance Test. The average arm, leg, core, and overall strength scores for all three groups of children with emotional, behavioural, and pervasive developmental disorders was categorized as "Below Average" (Emck et al., 2011).

Having increased strength can be a large benefit in children with disabilities (Bakker et al., 2002; Tsai et al., 2017). Among children with Attention Deficit Hyperactivity Disorder, higher levels of aerobic capacity, muscular endurance and power are related to greater selective attention and shorter reaction times (Tsai et al., 2017). Children with degenerative disabilities also benefit from having increased strength. Bakker and collegues (2002) found that children with Duchenne Muscular Dystrophy who showed lower levels of hip extension and ankle dorsiflexion strength were more likely to stop ambulating within two years and require the use of a wheelchair.

## Equestrian Vaulting

Although improved strength and fitness is mentioned as a benefit of participating in equestrian vaulting (Oakford, 2018), there is hardly any research. Schwesig and colleagues (2008) found that experienced vaulting riders had significantly better balance and postural control than show jumping competitors. However, as the Schwesig and colleagues' study was cross-sectional, therefore it is unclearwhether vaulting improved the riders' strength or if stronger individuals were competing in vaulting. Anecdotally, Temple and colleagues (2019, p.38) reported that summer camp vaulting activities included "...large number of activities requiring muscle strength during the floor, barrel, and horse-related practices". However, Temple and collegues (2019) did not measure these strength activities, but found that the child vaulters engaged in moderate-vigorous physical activity (MVPA) for 19 percent of the camp time (Temple et al., 2019).

### Rationale for a Pilot Study

There are many reasons to conduct a pilot study. These include developing and testing research instruments and protocols, evaluating study feasibility and the ability of researchers to recruit and retain participants, to collect preliminary data, and to convince funding bodies that the research study is worth funding (Van Teijlingen & Hundley, 2001).

Participation in muscle strengthening activities is a less examined component of public health physical activity guidelines for children and youth. In part, the lack of focus on strength is associated with the difficultly of measuring strength activities during participation. Consistent with the reasons why pilot studies are conducted, the aim of this pilot study was to provide evidence of the concurrent and predictive validity of a tool developed to measure engagement in strength activities during an inclusive equestrian vaulting camp. The following specific research questions were addressed: (a) to what extent did vaulters with and without a disability engage in strength activities and physical activity during camp? (b) to what extent did each major camp context (stable chores, runway, barrel vaulting, and horse vaulting) contribute to physical activity and strength activities? (c) did the strength measures predict engagement in the strength activities, and (4) what is the relationship between MVPA levels and strength activity engagement?

## Materials and Methods

### Setting, Design, and Sampling Procedures

This pilot study was set in the Cowichan Therapeutic Riding Association's (CTRA) 2019 inclusive equestrian vaulting camp summer for vaulters with some level of experience. The sample was purposive (Henderson et al., 2017) as each camper was a registered camp participant prior to recruitment into this study. All were experienced vaulters with between 1 and 3 years of involvement with the CTRA. We invited all six of the camp participants to join the study. Parents or guardians (if under the age of 19) or vaulters of legal age ($n$ = 1) provided consent and all vaulters assented to participate in the study. The Human Ethics Research Board of the University of Victoria provided ethics approval for this study (Protocol 20-0289).

### Participants

Each of the camp participants took part in the study and none dropped out during the week. All vaulters were female, aged between 11 and 22 years ($M$ = 14.2 years, $SD$ = 4.0 years), and had an average of 1.8 years ($SD$ = 0.8 years) prior vaulting experience. Diagnoses of disability or health conditions were obtained from camp intake registration forms completed by parents or guardians. Four of the vaulters had a diagnosed condition and two did not. To maintain vaulter anonymity the specific conditions are not described in this study, however vaulters had a range of neurological, intellectual, metabolic, and psychiatric conditions. The vaulters' height was measured using a portable stadiometer to the nearest 0.1cm and weight was measured on a digital scale to the nearest 0.1kg The vaulters' mean height was 148.9 cm ($SD$ = 4.2, range 142.0 – 155.0,) and average weight was 41.6 kg ($SD$ =

8.0, range 33.9 – 52.5).The weight status of all vaulters was within the normal healthy weight range. For the five vaulters under 20 years of age, the mean BMI percentile was 36.0 (*SD* = 27.8, range 9.0 – 38.9) and for the vaulter aged 22 years, her BMI was 23.1.

## Measures

### System for Observing Fitness Instruction Time (SOFIT)

Vaulters' physical activity and body position was coded using the SOFIT tool (McKenzie, 2002). Physical activity is recorded using SOFIT on an ordinal scale that ranges from 1 to 5. Code levels 1, 2, 3, and 4 comprise of lying, sitting, standing, and walking, respectively. Code level 5 is considered very active, where more energy is expended than in ordinary walking, irrespective of body position. Construct validity of SOFIT coding has been established in the laboratory and the field through comparison with participant heart rate response and has been shown to have excellent reliability (McKenzie, 2002; McKenzie et al., 1991). SOFIT has been widely used to examine physical activity levels among children with disabilities (Houston et al., 2018). In addition, we recorded the vaulter's context (runway, barrel vaulting, horse vaulting, or stable chores) when physical activity was coded.

As per the SOFIT training manual (McKenzie, 2002), momentary sampling was used to code the physical activity level and the context. The primary coder used an app on their smartphone to beep every 20 seconds to cue the observe – record cycles. A double beep cued the "observe" interval, which allowed the coder to orientate to vaulter's context and behaviour, and a single beep cue the "record" interval. The coder noted the vaulter's physical activity and context at the 'record' signal, and then had 20-seconds to write down the codes and prepare for the next observation interval.

### Hand-grip strength, push-ups, and curl-ups

Aspects of muscular strength were measured individually and privately, with only the test administrators and the vaulter in the room. Hand-grip strength was measured using the Takei Hand Grip Dynamometer (Takei Scientific Instruments Co, Toyko Japan). This test involved standing with a straight arm with the dynamometer held 45 degree from their side and squeezing the grip as hard as possible once. Each vaulter completed the test twice with their dominant hand and twice with their non-dominant hand, with a rest period of 30 seconds between tests. The highest score for each hand was recorded. Push-ups and curl-ups were completed in accordance with the Brockport Physical Fitness Test procedures (Winnick & Short, 1999). The cadence for both tests was cued using a phone app and each test ended when the vaulter could not maintain the cadence, stopped to rest, or chose to stop. We did not count incorrect performances. The push-ups test, which measures upper body strength and endurance, involved completing as many full 'plank style' push-ups as possible on a mat at a cadence of 1 every 3 seconds. Each correct performance, starting with the body and arms straight, then bending the arms to 90 degrees and returning to straight was recorded. The curl-up test, which measures abdominal strength and endurance, involved completing as many curl-ups as possible to a maximum of 75 at a cadence of 1 every 3 seconds. The starting position was lying on a mat with the knees bent at approximately 140 degrees and arms outstretched on the mat, palms down. The vaulter had to slide their hands 11.5cm along the mat to a piece of tape as they curled up. One curl-up was recorded when the vaulter returned to a supine position.

### Strength Observation during Vaulting (SOV) tool

Prior formative evaluation of a CTRA inclusive vaulting camp (Temple et al., 2019) evidenced that the vaulters were highly active during the camp and engaged in many activities that required considerable strength. Subsequently, we attempted to measure muscle activation during a vaulting camp using electromyography. However, the approach was ultimately not feasible. The positioning of electrodes, recorder, and wires on the vaulter had the potential to contuse the child, the horse, or both during vaulting activities. The issue of horse and vaulter safety is consistent with the rules of equestrian vaulting (Equestrian Canada, 2020). Because the vaulters are performing gymnastics style moves on the horse, no accessories (e.g., jewellery and belts), props (e.g., capes and gadgets), or hard soled shoes may be worn, and unlike other equestrian sports, helmets are not permitted while vaulting. Therefore, to safely assess the strength requirements of the inclusive vaulting camp activities, an observational approach was employed.

The following approach was used to develop the SOV tool:

1. Digital video of the formatively evaluated vaulting camp (Temple et al., 2019) was carefully analyzed by the authors VL, AN, and RB to identify higher strength activities in each camp portion. By consensus, these researchers found that four segments of the camp: stable chores, floor-work (known at the CTRA as 'runway'), barrel vaulting, and horse vaulting, comprised the majority of the higher strength demanding activities during the camp.

2. In each of the camp segments, specific strength activities such as sweeping the barn, performing a kneeling-scale on the horse or barrel, and jumping along the mats were identified. Each activity was described, the major muscle groups ascertained, and where appropriate, loads were recorded (e.g. weight of a full water bucket). Authors AN and RB re-created and performed activities offsite at the University of Victoria, using kinesiology principles and applied functional anatomy techniques to identify the major muscles working during each activity.

3. Because the intensity level of each activity could vary or the activity could be modified to increase or decrease the level of difficulty, a 5-point ordinal scale to represent levels of strength involved was developed for 13 floor-work activities, 10 vaulting activities, and six stable chores. A score of '1' meant that the activity required only a little strength, while an activity with score of '5' involved maximal or sub-maximal strength from the vaulter. However, not all activities were coded across all five levels. For example, the runway activity of "Inchworm" was coded as either '3' if the child inched their hands forward, but did not assume a plank position, or '5' if they inched their hands forward and could adopt the plank position. Whereas the "Forward Swing" vaulting activity could be scored as 2, 3, or 4. A vaulter scoring '2' for the Forward Swing shows little body tension and floppy movements, a "3" shows bent arms and legs with support on the surcingle, and a '4' shows a strong core and full upper body support during the movement.

4. The development of the scoring tool used Delphi methods (Dalkey, 1969) for expert contribution. The draft SOV tool developed in step 3 was emailed to two CTRA vaulting experts for their review. Both instructors had Canadian Therapeutic Riding Association Instructor certification (Senior and Intermediate) and were qualified Equestrian Vaulting Association of British Columbia Provincial Vaulting Trainers. One of the instructors was also an Equine Canada Competition Coach. These experts were asked to review the description of each activity and the intensity levels for clarity, completeness, and accuracy in relation to child vaulters. Following their review, a face-to-face meeting between the experts HS and DV and the researchers LS and VT was held to achieve consensus on the scale elements. An example for one strength element is displayed in Table 1, and the complete SOV tool is available in Appendix A.

**Table 1.** An example of how a barrel vaulting activity was coded for strength engagement. 'Not Applicable i.e., N/A' was used if that level of code was not appropriate for the particular activity.

| Activity | Description | Muscles | Intensity codes |
|---|---|---|---|
| Flag on the barrel  | Vaulter kneels on horse's back with an outstretched arm and leg (opposite). Supporting leg is placed slightly diagonal across horses back. | Strong arms and shoulders are needed to support. The gluteal, hamstring, and lower back muscles contribute to lifting and holding the leg position. | N/A<br>N/A<br>Body position or arms weak, extended leg not straight or below buttocks<br>Between '3' and '5'<br>Arms held about 60 degrees and supporting weight, shoulders over hands, strong body position, leg straight and extended above buttocks. |

5. The final SOV tool consisted of three sections: Runway activities, Barrel and Horse Vaulting Activities, and Stable Chores. Strength elements were identified in the SOV tool for each of the following sections (1) Runway: Dolphin, Bear, Inchworm, Kangaroo, Frog, Crab, Donkey Kick, Lizard, and Cheetah. (2) Barrel and horse vaulting: the Mount, Superman, Basic Seat, Bench, Flag, Bailing, Kneel, Forward Half Mill, Forward Swing, and Transitions between elements. (3) Stable chores: cleaning and filling buckets, wheeling buckets, sweeping, raking stalls, emptying the wheelbarrow, and collecting wood shavings.

**Procedure**

The study involved passive participation of the research team in an equestrian vaulting summer camp. Meaning that the researchers were present and video-recording camp activities and they measured the vaulters' strength, but otherwise, interactions with vaulters and instructors was minimal.

Typical for an inclusive vaulting camp for children (see Temple et al., 2019), specialized horses and instructors were used to facilitate the camp activities. Vaulting equipment included vaulting tack; girth, surcingle, under-pad, lunging equipment, and four practice barrels ranging from 1.02 to 1.65 meters in height. The tallest barrel was approximately the size of a vaulting horse. Instructors utilized gymnastics mats and a springboard for the runway activities, and brooms, rakes, buckets, wheelbarrows, and water hoses were used for stable chores. Each vaulter was required to have appropriate attire, including athletic clothing, shoes or boots for stable chores, and soft-soled shoes e.g. water or vaulting shoes for vaulting and barrel activities.

The research team attended each of the five days of camp from 9:00 am to 3:00 pm for the entire duration. In chronological order, a typical day at camp consisted of, arrival and welcome, stable chores on most days, warm-up activities, runway activities, barrel station work, snack break, grooming and tacking the horse, preparing to vault by practicing on the mats and barrels, performing compulsory exercises on the horse, thanking and grooming the horse, practicing freestyle routines and pair moves, and then lunch. After lunch, the vaulters again practiced on the barrels and floor, continued to create their routines, and performed their routines on the barrels and another horse. That horse was also tacked, groomed, and thanked. Stretching and practicing group balances were also components of the camp in the afternoon. Three certified instructors and one instructor in training led the camp. One of the certified instructors was an experienced lunger and one of the instructors was apprenticing as a lunger during the camp. The lunger warms up and works the horse at the end of a long line.

Each vaulter was videoed on two days of the 5-day camp by a videographer who followed the vaulter throughout the day, including transitions between activities. Videographers attempted to be as discrete as possible, while still recording audio and video. Videos were then downloaded onto the computer for subsequent coding and analysis. On average, each vaulter was video recorded for 200 minutes in the four contexts (Runway activities, Barrel and Horse Vaulting Activities, and Stable Chores) across two days.

**Data Treatment**

For this study, only time spent in the following contexts was coded: runway activities, barrel vaulting, horse vaulting, and stable chores. Time spent in warm-up activities, floor practice, games, lunch breaks, tacking and grooming, and transitions were not included in this study as the proportion of time in those contexts was small (e.g., games) or the engagement in physical and strength activities was low (e.g., breaks and transitions).

*Physical activity levels.* SOFIT codes 1, 2, and 3 were summed and given the label "Sedentary behaviour", code 4 (walking) was interpreted as "Light-Intensity Physical Activity" (LPA), and code 5 was MVPA. The number of 20-s intervals at each intensity in stable chores, runway activity, barrel vaulting, and horse vaulting was recorded from the videos. These intervals were then transformed into minutes and seconds for ease of interpretation.

*Strength activities.* Each video for each vaulter was watched from beginning to end by research assistants and the time in seconds in each of the four contexts was tallied. Within each context, the number of seconds spent in strength activities at each intensity level of the SOV tool was recorded.

**Data analyses**

Descriptive statistics were computed using IBM SPSS Version 27 for the vaulter's age, height, weight, years vaulting, BMI percentile, and time spent in in sedentary behaviour, LPA, MVPA, time in each level of muscular strength test, and overall time in muscular strength activities. As the amount of time in each context differed, physical activity levels and strength were also examined as a proportion of total camp time and time spent in each context. To provide an indication of predictive validity, we used linear regression to examine whether the three strength measures predicted time spent in the most demanding levels of strength that is SOV levels 4 and 5, which are characterized as controlled movements with good form (see Appendix A). A series of Mann-Whitney tests and effect sizes ($r$) (Field, 2013) were used to examine whether muscular strength, strength activities, and physical activity engagement differed between vaulters with and without a disability/health condition. Concurrent validity was examined by computing bivariate correlation coefficients between time spent in MVPA from SOFIT and time spent in SOV levels 4 and 5.

## Results

Table 2 shows the median scores for the three strength measures and for observed physical activity and strength engagement for all vaulters, as well as for vaulters with and without a disability or health condition. The main findings of this study were (1) that the three measures of strength accounted for 98.7% of the shared variance with time spent in level 4 and 5 strength activities ($R^2 = .987$, $F(2, 5) = 49.35$, $P = .020$), and (2) that there was moderate-to-strong concurrent validity between SOV levels 4 and 5 with MVPA. Bivariate correlation coefficients were $r = .73$ for all contexts, $r = .89$ for runway, $r = .64$ for barrel vaulting, $r = .76$ for horse vaulting, and $r = .81$ for stable chores.

## Engagement of vaulters with and without a disability or health condition

From the Mann-Whitney tests, there were no statistically significant between group differences for any of the variables. However, the effect sizes were large for push-ups, curl-ups, sedentary behaviour, total strength and strength levels 4 and 5. Effect sizes were also moderate for MVPA and Total PA (Table 2).

**Table 2.** Median (Mdn) scores, interquartile range (IQR) and Mann-Whitney test (U) results comparing muscular strength and time spent in physical activity and strength activities of vaulters with and without a disability/health condition.

| Variables | All (*n* = 6) | | No Condition (*n* = 2) | | Disability or Health Condition (*n* = 4) | | Mann-Whitney test | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mdn | IQR | Mdn | IQR | Mdn | IQR | U | p | ES[4] |
| Grip strength (kg)[1] | 20.8 | 10.4 | 22.8 | - | 18.3 | 11.1 | 3.00 | 0.800 | 0.19 |
| Push-ups[2] | 7.5 | 10.0 | 18.5 | - | 6.5 | 4.0 | .001 | 0.133 | 0.76 |
| Curl-ups[2] | 14.0 | 25.0 | 47.5 | - | 9.5 | 7.8 | .001 | 0.133 | 0.76 |
| Sedentary behaviour[3] | 96:04 | 32:87 | 71:00 | - | 102:10 | 11:30 | 8.00 | 0.133 | 0.76 |
| LPA[3] | 18:05 | 13:45 | 19:33 | - | 18:05 | 14:85 | 5.00 | 1.000 | 0.19 |
| MVPA[3] | 67:68 | 42:40 | 89:67 | - | 62:41 | 32:13 | 2.00 | 0.533 | 0.38 |
| Total PA[3] | 88:16 | 53:02 | 109:00 | - | 83:16 | 42:81 | 2.00 | 0.533 | 0.38 |
| Total strength | 40:65 | 28:76 | 57:77 | - | 32:85 | 14:93 | 10.00 | 0.133 | 0.76 |
| Strength levels 4+5 | 22:50 | 21:14 | 41:81 | - | 19:13 | 6:85 | 10.00 | 0.133 | 0.76 |

*Note*: [1] The standard scores for dominant hand grip strength are from Colley et al. (2019) (age 19 and under) and Wong (2016) (over age 19) and , [2]the standard scores push-ups and curl-ups are from the Brockport Physical Fitness Test (Winnick & Short, 2005). [3] moderate-vigorous physical activity (MVPA), Light-Intensity Physical Activity (LPA), and Total Physical Activity (Total PA) results are displayed in minutes:seconds. [4]Effect size (*r*) thresholds, small < 0.3, medium 0.3 – 0.5, and large > 0.5 (Field, 2013).

## Physical activity and strength engagement by camp component

MVPA was highest during barrel activities and low during stable chores and runway activities as presented in Table 3. Of the total observed time, the highest number of minutes of sedentary behaviour occurred during barrel activities however, this was partly a function of the greater number of minutes observed in that context. When the proportion of time at each intensity level within each camp context was considered, vaulters had the lowest proportion of time in sedentary behaviour during barrel activities. During runway activities, vaulters spent the most time in sedentary behaviour and the least amount of time in MVPA. Vaulters spent one-quarter of their time walking during stable chores.

The average number of minutes spent in strength Levels 1-5, as well as the proportion of time in strength activities during stable chores, runway activities, barrel vaulting, and horse vaulting is shown in Table 3. While vaulters were engaging in strength activities, the most time was spent in Level 5 – very high – intensity and less than 1% of total time was spent in Level 1 intensity activities. Vaulters were most highly engaged in strength activities while practicing on the barrels and least engaged while engagind in stable chores.

**Table 3**. Average time (minutes and seconds) and SOFIT physical activity levels in four vaulting camp contexts.

| | Observed minutes and seconds (min:sec) spent in each camp context | | | | Proportion of time at each intensity level within each camp context1 | | | |
|---|---|---|---|---|---|---|---|---|
| | SC | RW | BV | HV | SC | RW | BV | HV |
| SOFIT1 levels | | | | | | | | |
| Sedentary | 6:27 | 23:33 | 41:40 | 25:40 | 43 | 64 | 40 | 62 |
| LPA | 3:47 | 7:07 | 7:33 | 5:13 | 25 | 19 | 7 | 13 |
| MVPA | 4:53 | 6:20 | 55:13 | 10:47 | 32 | 17 | 53 | 26 |
| SOV levels | | | | | | | | |
| 1: Very Low | 0:11 | 0:00 | 0:00 | 0:00 | 3 | 0 | 0 | 0 |
| 2: Low | 2:25 | 0:09 | 1:06 | 0:03 | 40 | 5 | 3 | 2 |
| 3: Medium | 2:17 | 1:01 | 7:00 | 0:40 | 38 | 31 | 21 | 21 |
| 4: High | 0:53 | 0:28 | 11:09 | 1:22 | 15 | 14 | 34 | 43 |
| 5: Very High | 0:14 | 1:33 | 13:34 | 1:04 | 4 | 47 | 42 | 34 |
| Total 4 + 5 | 1:07 | 2:01 | 24:43 | 2:26 | 19 | 61 | 76 | 77 |

Sedentary = SOFIT codes 1, 2, or 3, Light-intensity physical activity (LPA) = SOFIT code 4, moderate-vigorous physical activity (MVPA) = SOFIT code 5. SC= Stable Chores, RW = Runway Activities, BV = Barrel Vaulting, and HV = Horse Vaulting.

## Discussion

The overall aim of this pilot study was to provide evidence of the concurrent and predictive validity of a tool developed to measure engagement in strength activities during an inclusive equestrian vaulting camp. We described the engagement of vaulters with and without a disability/health condition in strength activities and physical activity during camp. Further, the extent to which each major camp context (stable chores, runway, barrel vaulting, and horse vaulting) contributed to physical activity and strength activities was examined.

Content validity of the SOV tool was established by first identifying specific strength elements from video of a previous year's camp. Those videos had been used in systematic observation (see Temple et al., 2019). These strength elements were then analyzed by the research team for the major muscle groups involved and level of strength demands e.g. lifting an empty wheelbarrow compared to one loaded with wood shavings. Highly qualified vaulting coaches reviewed the specific elements and level of strength demands for inclusion in the SOV tool. Subsequently, the research team and the coaches achieved consensus on the scale elements. The process of achieving consensus on scale elements by combining the expertise of researchers in the field of kinesiology and equestrian vaulting is a strength of this study. This combination of professional and experienced-based expertise in important for innovation in the field (Birko et al., 2015) and bridging the knowledge-to-action gap in implementing research findings (Yeung et al., 2021). Following the establishment of content validity, this study demonstrated that the construct validity (both predictive and concurrent validity) of the SOV tool was more than adequate. Also consistent with the intent of a pilot study (Van Teijlingen & Hundley, 2001), we found that the study procedures of videoing and measuring strength were feasible, and we were able to recruit and retain all of the youth attending the vaulting camp.

This validation work occurred in situ, in the context of a typical CTRA inclusive equestrian vaulting camp. The camp was typical in terms of the nature of the camp activities (see Temple et al., 2019) and the diversity of disabilities and health conditions of the campers. All of the vaulters were independently ambulatory and as the measured strength and physical activity results revealed, participants with and without a disability or health condition were able to perform the strength tests and engage in MVPA. The extent to which this observation tool might be appropriate for vaulters with limited strength or mobility has not been examined. The lowest measured strength scores of vaulters included in this study were 14.0 kg for grip strength, 3 push-ups, and 8 curl-ups. Although these scores are lower than demonstrated in other studies involving children with disabilities (Klavina et al., 2017; Pitchford & Leung, 2021); they may not be representative of children with more severe disabilites (Wouters et al., 2020) or degenerative conditions (Hogrel et al., 2020). Therefore, we recommend that additional validation work would need to occur for populations with very limited strength or mobility.

Our results also show that participants engaged in physical activity and strength activites in all four contexts. Based on a prior formative evaluation of a CTRA inclusive vaulting camp (Temple et al., 2019), we hypothesized that activities in four distinct camp contexts (runway, barrel vaulting, horse vaulting, and stable chores) required considerable strength. We found that overall the vaulters accumulated considerable time (more than 42 minutes) in strength activities during the 200 minutes of camp in the four observed contexts. This is an important finding from a health-related fitness point of view. Muscular strength has been declining among children and adolsencents in the last decade (Kaster et al., 2020). This volume of strength activities during only two days of observation is a substantial contribution to children meeting the physical activity guidelines that include muscle and bone-strengthening activities (e.g., World Health Organization, 2020). The finding is particularly relevant for girls, as data demonstrate that their muscular strength tends to plateau during adolescence, whereas boys' muscular strength generally increases during adolescence (Colley et al., 2019). Similar to our observations for physical activity, the most and the highest proportion of time in strength activities was during barrel vaulting. This may be because the vaulters in this study had some level of vaulting experience, thus they already knew the basic positions required for successful vaulting elements and may have developed muscle strength for those moves. Both experience (Busquets et al., 2016) and sport-specific strength (Oranchuk et al., 2020) allow for increases in the complexity actions and improvement in sport performance. Overall, the observations from this camp indicated that the SOV tool is a useful measure of engagement in strength activities in diverse activities associated with the sport of vaulting, including vaulting itself, practicing moves on mats, and completing horse care tasks (Smith, 2014; Temple et al., 2019).

The findings also demonstrated that equestrian vaulting is a sport and recreational activity that affords youth with opportunities to engage in strength activities. Strength tends to be the less examined component of the MVPA guidelines for health, that is, "Vigorous-intensity aerobic activities, as well as those that strengthen muscle and bone, should be incorporated at least 3 days a week" (World Health Organization, 2020, p. 25). Service organizations such as the CTRA and camps are a target for implementation of Canada's 24-hour Movement Guidelines for Children and Youth (Latimer-Cheung et al., 2016). Latimer and colleagues noted that children often spend a great deal of time sitting at recreation programs and camps. We too found that vaulters spent about half of their time in sedentary behaviours, but we also found that vaulters engaged in considerable MVPA and strength activities. Although we did exclude several segments of the camp, such as lunch breaks and transitions, what we did observe, showed that the participants accumulated MVPA, LPA, and strength activities at a high level across two days.

## Limitations

This pilot study occurred in a naturalistic camp setting, and every camper agreed to participate. To prevent overwhelming the setting with researchers with video cameras, each vaulter was observed for two of the five days. As such, there were differences in which portions of the camp were recorded for each vaulter. Additionally, stable chores were only observed on one day. However, collectively, more than 20 hours (200 min x 6 vaulters) of the camp were systematically observed to provide a solid snapshot of the vaulter's involvement in physical activity and strength activities. The vaulters in this study had between 1 and 3 years of prior vaulting experience. Whether the results seen in this pilot are applicable to less or more experienced vaulters needs further exploration. Equestrian Canada (2020) prohits any accessories such as belts, jewellery, and gadgets being worn while vaulting.

## Perspectives

Equestrian activities are important forms of sport, recreation, and therapy for many individuals. The effect of vaulting on physical health has received very little attention compared to other equestrian activities (Stergiou et al., 2017). In part, this lack of attention relates to the impracticality of wearing a monitoring device while vaulting because it may injure the vaulter, the horse, or both. In this pilot study, we identified major strength activities in four contexts (floor work, barrel vaulting, horse vaulting, and stable chores) of an inclusive vaulting camp for youth and developed an observation tool to assess participant's engagement in strength activities in these contexts while they were participating. Construct validity (both predictive and concurrent validity) of the tool was more than adequate.

**Author affiliations:**

1 School of Exercise Science, Physical & Health Education, University of Victoria, Victoria, British Columbia V8P 5C2 virginialefeaux@uvic.ca, lstuhill@uvic.ca, ambernordquist@live.ca, robb_6@hotmail.com, vtemple@uvic.ca

2 Cowichan Therapeutic Riding Association, 1843 Tzouhalem Road, Duncan, BC, V9L 5L6 helgi@ctra.ca. dani@ctra.ca

* Correspondence: vtemple@uvic.ca; Tel.: +01-250-721-7846

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