BalBoa: A Balancing Board for Handstand Training

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ABSTRACT[1]

Balance is an essential physical skill to master, but a challenging one given that it requires a heightened body awareness to control, maintain and develop. In HCI physical training research, the design space of technology support for developing such body awareness remains narrow. Here, we introduce BalBoa, a balancing board to support balance training during handstands. We describe key highlights of the design process behind the Balboa, and present a work-in-progress prototype, which we tested with handstand beginners and experts. We discuss feedback from our users, preliminary insights, and sketch the future steps towards a fully developed prototype.

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KEYWORDS

Physical Training; Balance; Proprioception; Body Awareness; Embodied Interaction; Handstand.

Figure 1: We held 3 Yoga workshops with 4 practitioners (1 man; 3 women): a certified Yoga instructor with 10+ years of experience; a skilled trainee with a background as circus artist; and two beginners in Yoga, who were also HCI researchers. The workshops generated >40 ideas, among which the seed of the BalBoa concept.

Figure 2: We held a Circus workshop with 3 senior circus artists and instructors (1 woman; 2 men, one being a professional specialist in handstands). They resulted in >20 technology ideas. The BalBoa concept also emerged and was further developed here, specifying details of its input (weight distribution on one surface, and between surfaces) and output (visual representation of these weight distributions)..

1 INTRODUCTION

Balancing, the ability of maintaining the body's center of gravity over the body's support base [3] can be challenging, since it involves elusive information about our body that we obtain through three senses: visual, vestibular (sensations of body rotation) and proprioceptive (sensation of body parts' position in space, in relation to each other and in motion) [3,10]. Many experience difficulties in perceiving and acting upon such sensory information [10], and hence struggle with balance. Yet, balance is a fundamental physical ability both in everyday life and in physical training [3], and it can be improved through systematic practice, together with our awareness and control of information from our vestibular and proprioceptive senses [3].

Our research group develops interactive training technology to support trainees to focus on, and develop, their proprioceptive sensibility [13,14]. Here, we present a work-in-progress prototype of BalBoa, a Balancing Board to support handstand training, one of the most challenging balancing exercises performed on the floor [4], and present in many fitness disciplines (e.g. Yoga, circus arts, gymnastics, cheerleading, pole dancing [4]). The BalBoa design concept emerged in a series of ideation workshops (Figure 1-2) with several handstand practitioners in two of those disciplines. It provides trainees with a real-time visualization of their weight distribution on and in between their hands. We present our first prototype, provide insights from the design process and a preliminary study with end-users, and discuss future steps towards a fully developed prototype.

2 BACKGROUND

Handstands are a challenging exercise and a great way to develop upper body strength, a sense of balance and alignment, and overall body awareness [4]. Many kinds exist, but in its basic form it involves balancing upside down and vertically on one's hands. Mastering handstands requires developing a good sense of a proper body alignment, maintaining the body's center of gravity over the hands [4]. To achieve it, a proper weight distribution throughout each hand, and in between them (fairly equally between the shoulders) is required [4]. This is difficult. Many do not place their shoulders over the wrist enough, and tend to neglect engaging the fingers. They do not reach a proper vertical position and carry too much of their weight on their hands below their wrists. Understanding this is challenging, due to the elusive nature of such proprioceptive sensations [10].

2.1 Interactive Technology to Support Proprioceptive Awareness and Development

With emerging body-based sensing technologies, a growing body of works in HCI centered on supporting proprioceptive awareness (e.g.[5,6,13]). A common design strategy has been what we call *exteriorizing proprioception* [13]: making proprioceptive information (about e.g. body movement, alignment, etc.) accessible through exteroceptive senses (visual, auditory, gustatory, olfactory, and tactile), which are usually easier to access, understand, and control [13]. In the domain of movement-based arts, works have used biofeedback technologies to augment e.g., breathing [6] and heart rate [5]. Yet, in physical training and HCI, the design space remains narrow [13,15]. Some interesting examples have used visualizations to augment e.g. weight distribution [11], or posture [2], leveraging vision's dominance over our other senses [12]. BalBoa

Figure 3: Circus artist exemplifying with sponges the idea behind BalBoa: a pressure reactive surface.

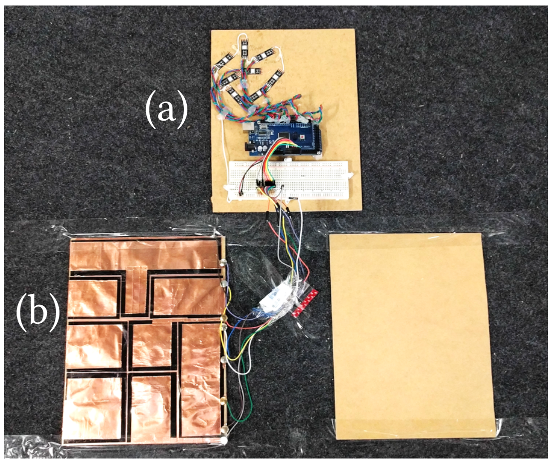

Figure 4: The first BalBoa prototype contains an Arduino Mega 2560 with 16 analogs inputs, used to monitor 8 pressure areas for each hand, and 54 digital Input/output pins, 48 of which can be used for 16 RGB LED outputs (8 for each hand) (a) to display the pressure on each sensor point. The pressure sensitive surface (b) is made of Velostat, a conductive fabric that varies the electric resistance when pressure is applied. It is connected to a R=1kΩ pull up resistor, and the oscillation of the electric current determines the pressure variation on the sensor.

follows the *exteriorizing proprioception* strategy through visualizations of weight distribution in and in between the hands.

3 METHODOLOGY

We follow a Research through Design approach [20]. In the broader research context of designing to support proprioceptive awareness in physical training, we organized several embodied design ideation workshops [14] (see Figure 1-2). Their goal was to open up the design space, generating interesting design ideas for training. We invited as co-designers practitioners of two somatic disciplines that require developing proprioceptive awareness: Yoga and Circus training (the latter including several disciplines, e.g. juggling, acrobatics, balancing). We used embodied design methods, such as Bodystorming [7,8], and Sensory Bodystorming [14] to support a hands on ideation, spur creativity, and facilitate a design-conducive space [8,14]. These support an embodied design approach by making use of the complete socio-physical setting as a design resource [8,9]. They support the generation of design ideas through physical and social engagement [8], and through objects with different material qualities providing rich sensorial stimuli [13] (e.g. sponges, clothespins, see Fig.1-3), used to envision and explore possible future sensors and actuators.

3.1 Design Concept Idea

Both workshops resulted in a wide array of ideas for technology inclusion, that ranged from solutions to improve overall body awareness, or specific performance aspects (e.g. body alignment, movement trajectory); solutions to scaffold movement mastery; and others to aid in instruction and error identification (see e.g. [14] for an overview).

Although none of the workshops particularly focused on handstands, they were frequently and prominently discussed. Our participants agreed that they are very challenging exercises that could benefit much from technology inclusion. All the handstand practitioners (the Yoga instructor,, and the four circus artists), identified a particular challenge: to understand and be able to correct their weight distribution on the spot, i.e. on their hands (fingers, upper palm and lower palm), and between their hands. They all said this was extremely challenging and impactful: a poor body weight distribution severely affected their balance, and thus their ability to perform a handstand. Given that separate workshops with multiple people surfaced the same challenge, which is also identified in literature on handstands [4], we conclude this is one of the most crucial aspects when performing a handstand.

In all the workshops, participants explored potential solutions to this challenge using the available props, which enacted the role of possible future technology (Figure 3). Many solutions involved pressure as input, e.g.: a sonified glove that would beep when the pressure was not evenly distributed, a screen-based visualization of pressure to allow reflection after the handstand. One particularly caught our and the practitioners' interest for its feasibility, versatility, and its potential to assist and have a real-time impact on performance for users with different skill levels: a pressure reactive surface providing immediate visual feedback to the practitioner, which would allow them to correct their performance in real time.

Figure 5: The first BalBoa prototype measures 8 key pressure points in the hand (upper left image). The device is reset when turned on, and from there, the pressure values are read every 50ms. A hand display, composed by 8 RGB LEDs (bottom-middle and right image) is mapped to the corresponding pressure points. The individual LEDs' colors are updated within percentages of applied pressure (see Figure below). The bottom-right image shows the pressure distribution of a hand, with maximum pressure applied to the middle finger (n°1), upper palm (n°4,5) and a point in the lower palm (n°7); and the less pressure in the thumb (n°8).

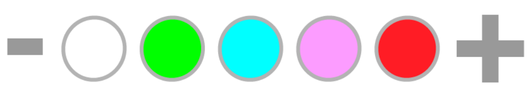

Figure 6: BalBoa's LED color scale reflecting incremental pressure, as follows: white (no pressure is applied); green (small pressure); blue (medium pressure); purple (high pressure); red (maximum pressure).

4 FIRST BalBoa PROTOTYPE

As a proof of concept, we implemented a first BalBoa prototype (Figure 4) focused on visually representing the weight distribution across eight key areas of the hand in real time (Figure 5). The prototype senses pressure through a pressure reactive surface, which is visualized on an adjacent panel through eight RGB LEDs, envisioned to placed be in the space between the two hands. Each represents pressure and amount of pressure of those eight points. (Figure 5). We implemented visual feedback to leverage the dominance of vision over other senses [12]. Also, the choice of RGB LEDs allowed us to represent pressure intensities in a nuanced way, by means of color changes.

The initial prototype features a wooden board similar to those used in handstand training to provide a stable surface. Affixed on top of it, two interactive panels are placed, one for each hand (see the left hand panel in Fig.4). The panel features a matrix of 8 distinct pressure sensing areas created with Velostat, which individually monitor pressure changes in real time (see Fig.4-5). The shape and size of these areas are designed to fit different adult hand sizes and in consultation with handstand trainees during and after our workshops. We took into account the main areas of the hand where weight is placed in a handstand: in its proper form, the weight should be placed fairly evenly between the areas 6-7, 4-5, and 1-2-3-8 (in Fig. 5). BalBoa reads each area's applied pressure, displaying a visualization of it in the LEDs set-up (Fig.5). The latter loosely matches a hand's shape: each LED corresponding to a pressure area (Fig.5), changing color according to the pressure applied as explained in Figure 6.

5 PRELIMINARY INSIGHTS

So far, we have tested this prototype in a circus training hall with 4 advanced handstand practitioners, and 3 beginners (Figure 7, next page). We introduced the prototype to them, and let them try it freely, both during warm-up exercises (e.g. on one's knees and hands on the Balboa, leaning on it with varied weight), and performing their handstand of choice (e.g. see Fig.7). Preliminary observations and feedback showed that BalBoa has potential. Our participants also confirmed the importance of augmenting their weight's distribution during handstands, and found the initial version of BalBoa useful to know about such distribution on one hand. The color coding (Fig.6) required explanation, but once explained, the participants found it easy to remember, and very informative. They praised the immediacy of the feedback and how it clearly showed changes in weight distribution. In addition, the participants surfaced two very important design considerations, which we will take into account for the next iteration of BalBoa:

Different Pressure Ranges for Different Hand Areas. In the initial BalBoa prototype, LED lights changed accordingly to absolute pressure changes on each hand area (1-8). However, our expert practitioners brought up that the different areas are able to, and should, support different amounts of weight. Although handstands involve an even distribution of weight in the different areas, in absolute terms, most of the weight is still on the wrist (i.e. lower palm). Given that BalBoa reacted to absolute pressure measures, many expert practitioners brought up that it did not accurately reflect the weight they felt. Onsite, we reprogrammed the BalBoa to address this issue, with a more sensitive correction factor for hand areas 1-3 and 8 with respect to areas 4-5 and 6-7, which

Figure 7: Practitioner performing an advanced handstand on BalBoa, looking at the visualization between his hands, positioned below the 2 sensing panels. Other practitioners wait for their turn.

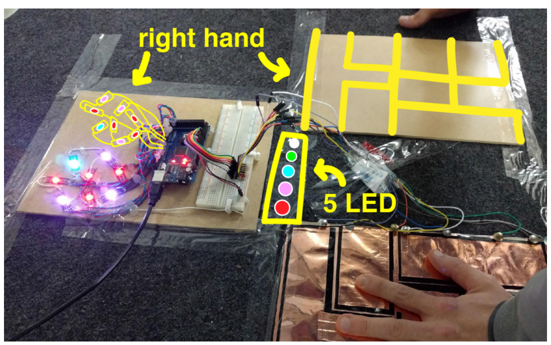

Figure 8: Sketch of BalBoa's next iteration. The right hand panel will be assembled, to have visualizations of both hands. A new 5 LED display will be added to visualize weight distribution between the two hands, with the same color-coding system. All the panels will be made rearrangeable.

triggered their corresponding LEDs at lower pressure ranges. The expert practitioners felt this correction better corresponded to their experience and was much more informative and useful.

Importance of Board Versatility. Throughout the testing, practitioners manipulated the hand and visualization panels, e.g. increasing or decreasing their distance and location, allowing collective modification of our initial prototype on the spot. All practitioners agreed that the hands visualizations were most useful below the hand panels, and not above, as we originally designed it. This is related to the ideal gaze orientation during a handstand: either in between the hands, or slightly forwards. The practitioners envisioned an arrangeable BalBoa with adjustable distances of the panels to accommodate for people of different sizes.

4 CONCLUSIONS AND FUTURE WORK

Through a series of ideation workshops, we have developed BalBoa, a device to support balance training during handstands. We are currently polishing BalBoa: a next iteration (Figure 8) will include a second reactive panel (for the right hand), using the resting 8 analog inputs of the Arduino controller board for pressure sensing and the corresponding LEDs. We will also include a similar LED output source (e.g. a 5LED stripe, Fig.8.) to show the weight distribution between the two hands. We will further explore differences when sensing weight in different hand areas, applying the necessary corrective factors to the fingers' area (most sensitive), the upper palm's and lower palm's (least sensitive). We will work towards making each of the boards in BalBoa (the two sensing panels and the visualization one) easy to rearrange and adapt to each practitioner's performance. Finally, we will conduct further user studies to evaluate the new iteration, particularly in regards to the envisioned visual feedback system, and to uncover its potential for handstand training.

BalBoa holds potential to contribute to HCI by extending the repertoire of design artefacts that center on supporting and enhancing body awareness, both in the domain of physical training (e.g. [2,10,12]), and more broadly, in the domain of movement-based interaction design (e.g. [5,6]).

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