dren), breast stroke (35%), and crawl (12%) as shown in Figure 3.

Surprisingly, the avatar animations (QuiQui's crawl) did not seem to restrict or direct the children's movements. Even though QuiQui moved from left to right, the children did not turn in the direction of the character until they were forced to change QuiQui's route in order to continue. This also means that QuiQui's animations had to be redesigned to better match the children's movements. Additionally, any earlier swimming training did not seem to fully correspond with their movements either, as could be seen in the popularity of the breast stroke, which Finnish children do not usually learn until they are 10 or 11 years old.

Although the children could easily imitate realistic swimming gestures with their hands, making a character dive up or down was more confusing for them. Here, the direction of the movement was key. To dive downward, the children continued swimming, but directed the movement toward the floor and accentuated that by bending their knees or upper body. To get QuiQui to rise to the surface, the children continued swimming, but with their arms above shoulder level. Some even jumped or rose on their toes.

Phase	Mean duration (in ms)	Post-phase height in relation to the children's head length.
Preparing	212.3	-0.65
Taking off	308.0	0.84
Landing	287.4	-0.41
Recovery	342.8	

The duration and height values of 130 jump samples. The height values represent how high or low the children moved in relation to the length of their heads at the end of each phase shown in Figure 3. The length of the head is one unit.

In the running game we tested how children controlled QuiQui's running, passing trees, and collecting butterflies by jumping. As opposed to various swimming and diving styles, the children's jumping was most similar across all participants. The duration and height values in the different phases of the jumps are shown in the table here. The preparation phase (crouching before taking off) could be used as a preaction cue to make vision algorithms react quicker when the actual jump begins.

Additionally, the game would behave more realistically if QuiQui crouched as well. The recovery phase gives a cue of when the next movement can begin, which in turn affects the pacing of the game. In general, if the game does not tolerate a long enough recovery period after a movement, children can become frustrated if they are not able to succeed due to their physical performance. However, the avatar doesn't necessarily need to follow the player's exact jump height (as long as the player knows how high the avatar jumps), but it is important that QuiQui responds fast enough when a child takes off.

The study of the video material also revealed some design issues to be studied further. Improper system latency leads to redundant actions and oscillation [4], which breaks the illusion of tightly coupled interaction. This could also be seen as the successive jumps by the player if QuiQui did not respond fast enough. When QuiQui was running in a field presented in a semi-3D perspective, the children were not sure when a butterfly was close enough to be caught. Thus, the avatar's range and distance from platforms or objects to be reached should be clear enough; otherwise children might accentuate their unnecessarily or approach the objects repeatedly.

To make QuiQui run, the children used both subdued (minor vertical alteration of the head level due to small leg movements) and lively movements. Surprisingly, there was a gender difference in the preference of these movements. Nine of the 11 boys favored subdued styles such as marching, strutting, or walking as shown in Figure 3. However, girls seemed to prefer more dynamic styles; 18 of the 25 styles the girls used were either running or swinging the feet from side to side. The problem with the subdued styles is they are difficult for the vision algorithms to recognize if the camera's field of view is only capturing the player's upper body and most of the movement is appearing below the waist. Thus, in the process of building a running game, the designers must pay attention to clear instructions and the presentation of the running avatar.

Even though there are individual characteristics in children's movements, patterns do exist **AND THIS INFORMATION CAN BE USED TO FURTHER IMPLEMENT BOTH COMPUTER-VISION ALGORITHMS AND AVATAR ANIMATIONS.**