

# Plea for Use of Lowered Toilet for All

Pamela MUSCH<sup>1</sup>, Maarten DEN HARTOG  
*Studio DenHartogMusch, Arnhem, the Netherlands*

**Abstract.** *Design study:* Applied research of biomechanics and anthropometric aspects of lower point-supported sitting and translation of the results into a lowered toilet concept with integrated point support. *Background:* In literature [1], the posture of squatting is biomechanically considered a healthier posture than the western toilet posture. For the western population, squatting proves to be a difficult and uncomfortable experience. By lowering the seat and combining it with point and foot support, a more comfortable squatting posture is created. In this article the lower point support posture is analysed and visualised in anatomical and ergonomic sense. *Prevention:* Furthermore, the expectation is expressed that the lower point-supported toilet concept will prevent problems with constipation, safety and hygiene. It is probable that after experienced use the (more flexible) elderly user will be able to use the toilet longer and more independently, albeit with some special adaptations. *Conclusion:* A plea for further research on and investigation into the preventive function of a lower point-supported toilet concept is expressed. Some solutions for further development are discussed in order to improve this toilet concept for the elderly user. *Recommendation:* The lower point-supported toilet concept presented in this article should be tested and developed further and should be regarded as a first step towards a preventive and healthy toilet for every adult, the elderly included.

**Keywords.** Squatting, elderly, toilet, pelvic floor muscle, constipation, support.

## Introduction

The increasing population of elderly people and the risks of dizziness and falling that come with age demand a safe and responsible design of toilets. For the elderly toilet user preventive measures are advertised widely: toilet seats with increased height and bathrooms with impressive adjustment functions. One cannot deny the fact of the actual 'seating' thus being made more comfortable, but considering almost any other aspect of toilet use (hygiene, increased problems of constipation, balance problems), these solutions overshoot the mark. They merely lead to an increased probability of constipation, to unhygienic situations and unnecessary tumbling risks. Tumbling risk occurs because of the loss of foot contact with the floor or because of the often inadequately placed support, most likely in the situation of toilet users with shorter arms and legs.

Snijders, Molenbroek and Plante already described the disadvantages of elevated toilet seats [3] and argued for rethinking the almost automatic installation of such toilets for elderly people. This article shows that a lower point-supported posture for toilet use may even be a better solution to solve the above mentioned problems.

In literature [2] the squatting posture appears to be the most natural one in which unobstructed and hygienic toilet use is possible. The deeper the squatting, the less

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<sup>1</sup> Contact information:

obstruction of the bowels. Because the feet are in good contact with the floor, the risk of tumbling is decreased, which makes the squatting posture a safe option.

Of course, for the elderly toilet user, the squatting posture is unquestionably more difficult to realize than sitting down on an elevated toilet seat. This is also true for the younger toilet user: squatting definitely takes more effort and causes more strain than regular sitting on a toilet. This, of course, raises the necessary questions concerning the idea of a lower point-supported toilet, especially in relation to the elderly.

Besides this, the use of conventional squatting toilets meets with many psychological barriers in the western society. Objections are of a both physical and psychological nature[2]:

- squatting is regarded as unhygienic, clothes get dirty easily
- squatting is not at all easy and 'directing' is difficult
- keeping balance is difficult
- large strains occur on leg muscles and knee joints, especially when squatting longer

In this applied research the central question was how to find a proper way to create a (kind of) squatting toilet posture that provides a more comfortable experience than the native squatting posture. This resulted in a lower point-supported toilet concept. Secondly, possibilities to improve hygiene and user comfort (clothes, cleaning buttocks) in comparison to the conventional squatting toilet were examined. In conclusion, adaptations to the lower point-supported toilet concept for the elderly user were looked into.

The argumentation in this article leads to the conviction that the (preventive) use of a lower point-supported toilet offers a healthy, hygienic and safe solution for users up to old age.

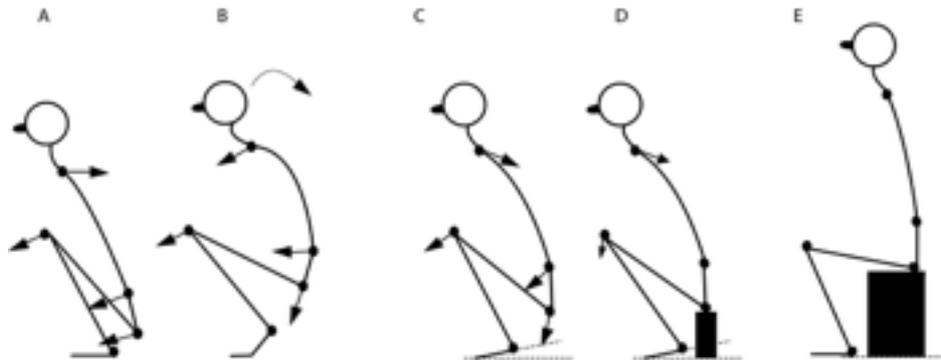
## **1.Methods**

The described study contains a literature study of the squatting posture and a physical (interactive) study of the lower point-supported sitting (with a mock-up and a questionnaire). These formed the basis for a design study in which a lower point-supported toilet concept was created.

### *1.1.Study of the Squatting Posture*

The posture of the conventional squatting toilet (with a 'hole' in the ground) is very similar to the native squatting posture in some Asian countries, for example Indonesia. In literature, this posture is considered to be a better posture than the posture of the western toilet with its seat at an average height of 42 cm [1].

When squatting, the bowels are stimulated, the muscles around the pelvic floor are not strained, and the buttocks are spread which is far more hygienic (reduction of the need for cleaning).



**Figure 1.** Various squatting postures, lower point-supported seating and regular seating

Native unstrained squatting posture (A), western or inexperienced squatting (B), squatting with foot support (C), squatting with foot support and point support (D), regular sitting (E)

The native squatting posture (with feet flat on the ground, see fig. 1A) is a comfortable posture, but it requires flexible ankles, hips and knees. Most of the western population can hardly attain this posture because of the lack of flexibility in these joints. The differences between Asian and western populations can be attributed to a combination of inexperience and a different structure of joints and muscles.

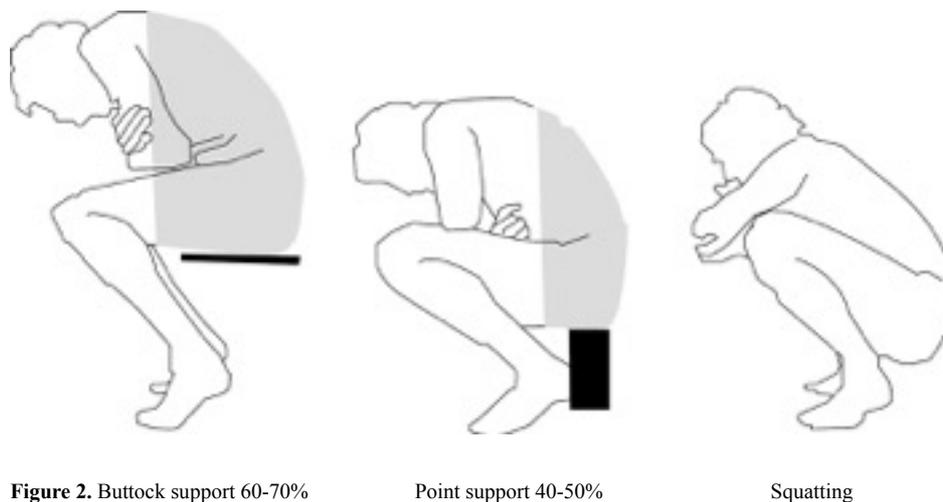
The (inexperienced) western squatting posture looks like figure 1B. This posture leads to a lot of strain on the calves, and the knees are relatively heavily loaded. Many people find it difficult to get up out of this posture, particularly because of balancing problems. For going into and getting up from the squatting position, the whole body has to cooperate. By far the largest contribution to the total effort is delivered by the legs.

### *1.2. Squatting Less Deep, a Logical Solution*

The dexterity with which people can go into a squatting position depends on the length, size and flexibility of their joints, and also on practice, therefore it can vary considerably per person. If we examine the native squatting posture (fig. 1A), the distance of the buttocks to the ground varies from 150 – 205 mm. A wedge support at an angle of 15° under the heels makes squatting more comfortable (fig. 1C). In this particular squatting posture, the buttocks are a little higher, and the distance of the buttocks to the ground varies between 230 and 280 mm [4]. Squatting with the use of a foot support makes both getting up from and going down into the squatting posture easier and also enables better balance. Even more comfortable than squatting with a foot support is the lower point-supported posture (fig. 1D), in which a large part of the body weight is transferred to the point supports (see also fig. 2). Their height is 25.5 mm, which is an average height and 16.5 mm lower than the average toilet height of 42 cm. For illustration, the regular sitting posture is shown (fig. 1E).

### 1.3. Lowered Sitting Posture Ideal for Toilet

If we examine the various squatting postures (fig. 1A, 1B and 1C) and compare them to the regular sitting posture (fig. 1E), it appears that the sitting posture in respect to the stool has a disadvantage: the anteflexion of the hip joint will not be large enough to tilt the pelvis when spreading the legs, thus more or less obstructing the 'transit' of the faeces [3]. The sitting posture compared to the native squatting posture (fig. 1A), however, does have the advantage that leg muscles and knee joints are strained less as the swells carry the major part of the body weight (60/70% is carried by the seat, see also fig. 2). This advantage is quite similar in the situation of the lower point-supported posture (point support, see fig. 2B), where the support takes between 40 and 50% of the body weight off of the legs. Considering this aspect, the lower point-supported posture offers almost the same advantages as a regular toilet seat, on top of its other advantages in comparison to elevated toilets (low risk of tumbling, better transit of faeces, lower risk of constipation).



### 1.4. Further Studies

The forces in the lower point-supported sitting posture (fig. 2 middle) are carried by the ligaments and the muscles. The actual distribution of these forces and torques on every component (bone, tissue, muscles) theoretically has been determined, however has not been confirmed yet by measurements in practice. With these measurement data a more accurate validation of the profits of the lower point-supported sitting posture can be made.

## 2. Lowered Sitting as a Training for the Stool?

It has not been proven, but it seems logical to suppose that regular use of a point-supported lower toilet starting at young age will develop better muscle condition and flexibility for the user. Together with better posture (of the pelvis) this could help decrease potential constipation problems or maybe even prevent them in old age.

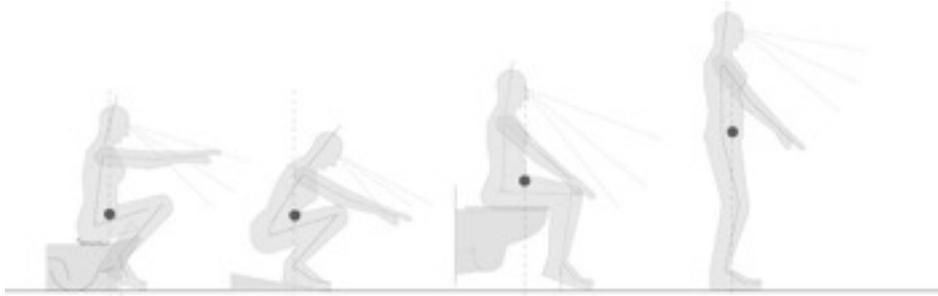
As the elderly population is not 'trained' in this respect, it is expected that inexperienced use of a lower point-supported toilet will most certainly cause problems. Solutions can be found in aids that help to start and support the movement at a higher level, and those that support the user during the downward movement into the lower supported position, including adequate aids to help the user get up again. A 'sit-stand' support will function in a similar way as current solutions for 'sit-stand' aids, only differing at the end position which is significantly lower than usual. By the way, every centimeter lower is already an improvement compared to the current toilet elevators.

It is known [Hill, 5] that a passive stimulation of muscles indirectly causes a training effect on those muscles working in the opposite direction. This also works for the use of the 'squatting' muscles during a supported movement, both for the movement of the actual 'squatting' and for the movement of getting up from out of the lower point-supported posture. We therefore may postulate the assumption that the lower point-supported toilet posture can be regarded as training for these muscles, with a matching expectation of positive side effects on potential constipation.

### 2.1. More Stability when Sitting Lower

The gravity centre of an upright sitting person on a regular toilet is about 20 cm behind the feet. (see fig. 3C). The exact distance depends on the body size of the user and on the actual posture of the user. Sitting down on a toilet seat requires a backward horizontal gravity centre displacement of about 20 cm, some 2/3 of the seat depth. To get up without using the arms, the user has to 'throw' the upper body forwards, which creates a momentum that brings the gravity centre above the feet again. Frequently, elderly toilet users are either not able to or do not dare to deliver this momentum. In that case the elderly toilet user will either choose to slide to the front of the seat, or will reach out for a support. Both choices create a risk of tumbling.

In the figure 3, a P50 woman is shown in four postures: lower point-supported sitting, squatting on a platform with a slope of 15°, sitting on an average toilet seat (42 cm height) and finally standing upright. The gravity centres in all postures are marked indicatively with a black dot.



**Figure 3.** P50 woman on point-supported seat, squatting on a sloping platform 15°, sitting on toilet (42 cm) and standing upright. The black dot indicates the gravity centre.

When sitting on a lower point-supported construction, the distance between the gravity centre and the feet is about 8 cm. Standing up from this lower point-supported posture is safer as it requires only leaning forward, thus bringing the gravity centre above the feet. Additionally, the fact that the legs are in good contact with the floor creates a very stable situation. To get up again there is no need to slide or reach forward, the user just has to stretch his legs. Only in situations where a toilet user (who is able to go into this lowered position) lacks muscle strength or stability, extra support will be necessary.

### *2.2. Lower Point Support more Hygienic*

In regular every day female toilet use the cleaning is practically realized by sliding forward and backward on the toilet seat. Men will probably prefer to stand up in order to clean, thus avoiding undesirable 'skin-seat' contact. The situation with increased toilet seat height creates difficulties for the elderly lady in this respect, since the opening quite often is significantly smaller. For small women with shorter legs situated at increased height, not being able to reach the floor, an unhygienic smearing of the seat can be the result.

On a regular toilet seat, skin contact with the seat is normal. The lower point-supported toilet concept reduces this skin contact to the point-support. In theory, the lower point-supported toilet concept shows an advantage with respect to hygiene. Since the faeces pass at close distance to the point support, the design of this support will have to be determined very precisely to enable the user to take place in exactly the right position and to create the conditions for hygienic use.

Similar to the squatting posture, the lower point-supported posture causes the buttocks to be more spread open, thus reducing the need for cleaning. For this reason the lower point-supported posture can more easily be combined with integrated hydration/dry systems because these systems will work more effectively. Hydration/dry systems also match the cultures in which the use of toilet paper is considered unhygienic. Without a hydration system, it is necessary to clean buttocks at the lower position, because when cleaning after getting up, the buttocks automatically join, with increased need for cleaning as a result. For the elderly user this raises the question whether it is possible to comfortably clean in the lower point-supported position. At the

same time one should question the stability of elderly persons sitting on a seat far too high for the legs to reach the floor, wanting to clean and not being able to do so without holding oneself with one hand or having to stand on the floor first, which causes a dirty toilet seat. A slightly more uncomfortable lower point-supported posture with both feet firmly on the ground might be preferred purely from a safety and hygiene point of view.

### *2.3. 'Pressing' Easier when in Squatting Posture*

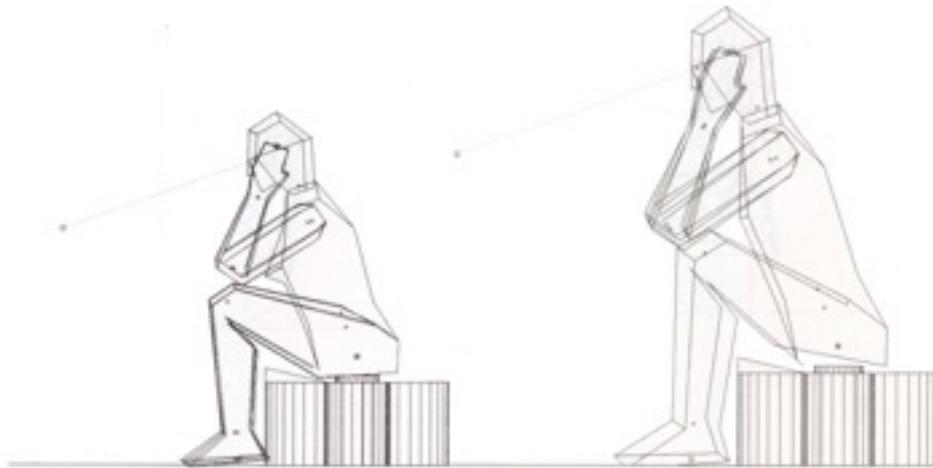
In literature [2] it is indicated that the squatting posture shows a relaxation of the muscles of the pelvic floor, so that the bowels are not obstructed during discharge. It is also mentioned that squatting enables a better possibility to press with the abdominal muscles [4]. The posture of the lower seat with point support seems to provide almost the same stimulating conditions for the pelvis to rotate and for the legs to spread, thus creating a situation for the upper legs to push back. This will result in a preventive advantage with respect to constipation problems.

## **3. Ergonomics of the Lower Sitting Posture**

With a regular toilet seat the user's weight is spread over the whole surface of the toilet seat. In the situation of the lower point-supported posture, more body weight is concentrated on a significantly smaller surface. This requires specific dimensions for the shape and comfort of the design of the point support. It also means that the legs will be actively used for balance. On average, adult buttock bones are some 25 mm wide and some 40-50 mm long, and the distance in between varies from 120 to 160 mm [2]. With female buttocks, this in between distance is on average some 20 mm wider than with male buttocks. For optimal comfort the buttock bones will have to be supported fully yet allowing for hygienic toilet use. The ideal point support opening therefore should lie somewhere between 75 and 90 mm. This demands a clever design, especially with respect to the space needed for cleaning both at the front and at the back side of the point support. Broad openings at the front and back side of the toilet seem a logical solution, since the user of the lower point-supported toilet will not be able to slide on the seat as usual. Finally it is important that the toilet offers enough space to place the feet as close to the gravity centre of the body as possible.

### *3.1. Ergonomic Demands for Lowered Sitting with Point Support*

The above-mentioned translation of the squatting posture anthropometry into a lower point-supported posture was first put into a geometric substructure. The research was at first focused on the able-bodied adult user up to an age of 55 years. The goal of the study was the development of a preventive toilet concept with an integrated point support to be used by everybody. Later it was decided to examine the concept for use by the elderly user as well. The geometric substructure was qualitatively examined by making use of the ADAPS programme, after which a foam mock-up (see fig. 5) was built that was tested by 20 people (wearing clothes).



**Figure 4.** ADAPS study

In the foam mock-up the point support is integrated at an average (free squatting) height (fig. 1C) of 25.5 cm, combined with a foot support in the form of a wedge with an angle of 15°. The ADAPS study above did not make use of this foot support. The support of 15° under the feet provides the user with some extra comfort and makes it more easy to go into the lower sitting posture [4].

### *3.2. Testing the Lower Sitting Concept*

A group of twenty test subjects with an average age of 27 years examined the lower point-supported sitting posture of the mock-up. On a questionnaire comments were given on the mock-up, on the movement necessary to go into lower supported sitting, on the comfort of the height itself, on the overall dimensions (space for cleaning), and on the appeal of the concept in general. The responses were used to improve the mock-up and to translate the mock-up geometry into a dimensioned and materialised global product design.

In figure 6 a ‘translation’ is shown of the geometric substructure into a contemporary looking lower point-supported toilet concept.

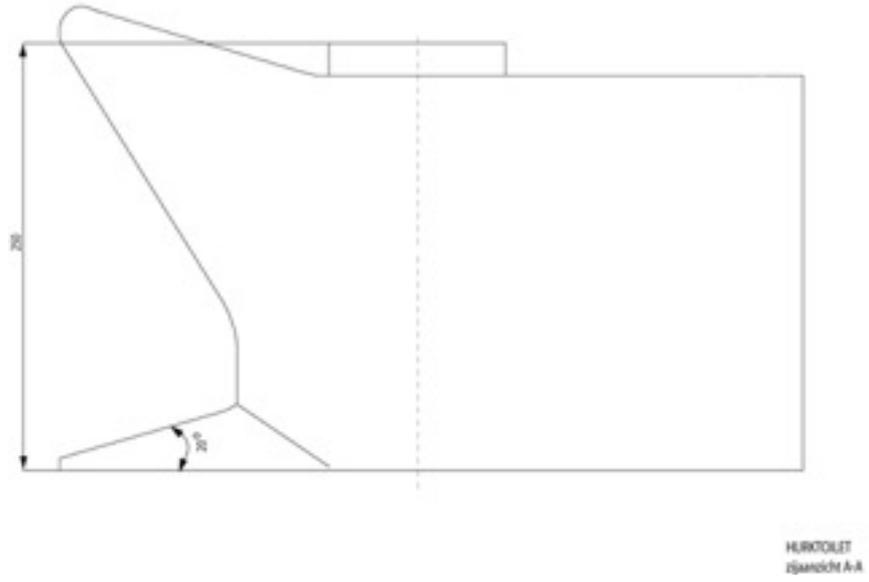
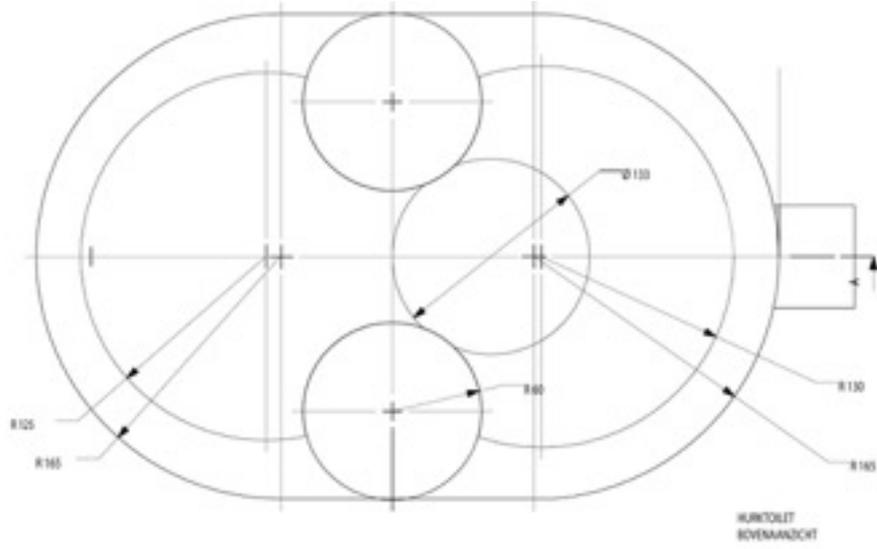


Figure 5. Dimensions of the mock-up



**Figure 6.** Materialized concept for lower point-supported toilet (front, side and top view) © Studio DenHartogMusch, Arnhem 1996.

#### **4.Increasing Elderly Population**

In 1996 it may have been too early to publish such an innovative toilet concept, but today in 2007, the time seems right for the insight that elderly people are (preventively) helped by a lower point-supported toilet. The main advantages of this concept are lower risk of falling, less constipation problems, and increased hygiene. All of this leads, in the long run, to a prolonged independent use of the toilet in old age. This vision, however, does require some adaptations of the concept shown above.

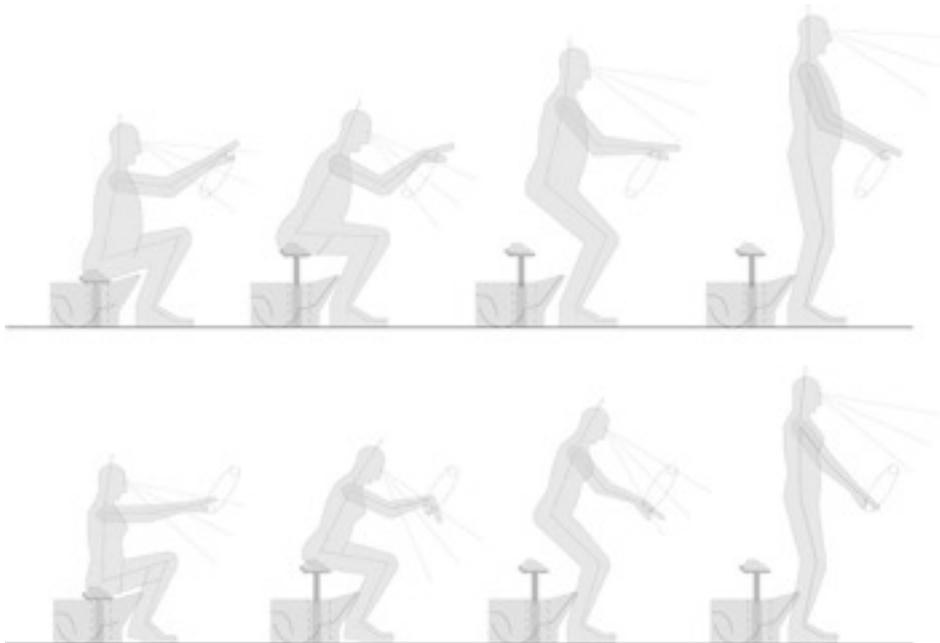
##### *4.1.Solutions for Adapting the Concept to the Elderly User*

Though the pictures of squatting elderly people in figure 7 do justify some optimism, elderly users in general will have trouble to go into a lower sitting posture, if they ever reach that posture at all. (In this respect we focus on the elderly that are still ‘flexible’.) To support the elderly user during the movement of going down and getting up from the lower point-supported sitting posture, the toilet can be provided with a seat lifter and a support bar, preferably in front of the toilet [3].

Figure 8 indicatively shows a possible position for such a support bar for a P95 male and a P5 female. Adaptations like the ones indicated here will probably be appropriate to adapt the concept of lower point-supported toilet to the elderly user, but the only way to examine this is by doing more research.



**Figure 7.** Squatting of a healthy elderly person (male, 75 years, 1.78 m, no support, feet flat with shoes, distance buttock to floor 25 cm; and female, 72 years, support, shoes, distance buttock to floor 23 cm, heels up).



**Figure 8.** (Above) indicatively supported lower sitting with sit-stand-up aid and support bar in front of P95 male, (below) indicatively supported lower sitting with sit-stand-up aid and support bar in front of P5 female

In any case it should be mentioned that in the situation of lower point-supported sitting the gravity centre is closer to the feet, so the forces necessary to stand up can more easily be delivered by the legs. In comparison to the situation on a regular toilet seat, this leads to a significant reduction of the arm force needed in the case of a small person, since both feet already touch the ground. From this viewpoint, the lower point-supported toilet offers a more stable situation and therefore justifies the expectation that it will offer a safer condition than the current elevated toilet seats. Further investigation is needed to provide proof for this statement.

Though still a lot of research has to be done to determine the definitive dimensions of the lower point-supported toilet and its additional supporting devices for the elderly user, there are strong indications that -despite the challenging movement of squatting for the elderly person- the concept of the lower point-supported toilet has serious user comfort to offer and may prevent many problems of hygiene, constipation and unsafety with conventional toilet seats.

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