RESEARCH ARTICLE

# Self-Reported Physical Complaints are Reduced Upon Regular Use of an In-Home Water Filter System (AcalaQuell®): A Prospective, Controlled, Documentation Study

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**Abstract:** ***Background***: The emerging public concern regarding the quality of drinking water has led to an increased interest in household water treatment systems. Many systems reduce contaminants effectively in laboratory tests, at least to some degree, but for the vast majority, their effects in actual use are not investigated.

***Objective***: To test the effectiveness of an in-home water filter system (AcalaQuell® Swing) in reducing health problems under real life conditions.

***Methods***: Twenty participants suffering from cardiovascular ailments, gastrointestinal issues, or fatigue/exhaustion symptoms were enrolled in the study. In the control condition (three weeks), they consumed 35ml of tap water per kg of body weight daily. After an intermission of one week, they drank the same amount of filtered water in the following three weeks.

***Results***: There was a large reduction in physical complaints after consumption of the filtered water (d = 1.4), and an increase in resiliency to physical and mental stress, cognitive performance, and affectivity (d = 1.0).

***Conclusion***: The AcalaQuell® Swing water filter effectively mitigates health complaints. The effect was not according to the expectations, and there was an increase in water consumption, a decrease in life stress, and spontaneous symptom remission.

**Keywords:** AcalaQuell®, effectiveness, in-home water filter system, mental fatigue, physical complaints, health problems.

## 1. INTRODUCTION

The presence of emerging contaminants in wastewater poses great health care challenges [1]. Many substances enter the wastewater treatment works unaccounted for because analytical approaches lack adequate treatment [2]. As pointed out by some researchers [3, 4], there are notable shortcomings in testing the accumulating number of toxic substances, among which are fertilizers, industrial waste products, environmental toxins, health care products, and pharmaceuticals. The unknown toxicological profile of wastewater poses a significant hazard risk due to pathogenic microorganisms, chemical residue, and nanomaterials [5]. Despite efforts to reduce the global burden of disease through the improvement of water supply, epidemiological data give a cause for concern [6]. For example, the continuous increase of heavy metals has led to their wide distribution in the environment [7, 8]. When entered into the ecosystem, they work their way into lakes, rivers, and oceans where they biomagnify in the food chain [9], and their relative resistance to metabolization or excretion makes them dangerous to health [10, 11].

The growing number of new emerging synthetic materials poses another threat. For instance, every year, millions of tons of highly toxic plasticizers accumulate in freshwater and water supply systems [12, 13]. In a study investigating anthropogenic contamination, it was found that more than 80 percent of the tap water samples contained fibers between 0.1-5 mm in length [14]. Recently, the presence of nine different microplastic types in stool samples, taken from several countries, was detected for the first time [15]. Even when drinking water standards for microbiological quality are met, the water can still be contaminated and contribute to the endemic levels of health deterioration (cf [16, 17].). The increasing public interest in this topic prompts health-conscious individuals to seek alternative solutions for the improvement of drinking water. The most common systems for households are point-of-use (POU) water treatment systems, ranging from distillation, reverse osmosis, activated carbon filters, ultraviolet treatment, or cation exchange resin beads, to name but a few.

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The question of whether these systems are useful is controversially discussed [18]. Critical opinions point to health and safety issues. For example, the use of such systems is not officially regulated and may promote detrimental effects, for example when the filters are not replaced frequently enough. On the other hand, there is evidence that filtering water at the household level might be beneficial. For example, a randomized, triple-blind, crossover trial involving several hundred households testing active versus sham filtering devices for 6 months found that the episodes of gastrointestinal illnesses were decreased when tap water was filtered with a 1-$\mu$m ceramic filter and treated with ultraviolet light [19]. Past systematic reviews which somewhat questioned the link between water sanitation and health problems [20] have since been replaced with ones that corroborate such findings. For instance, it was found that the use of water filters, high-quality piped water, and sewer connections were associated with greater reductions in diarrhea [21]. The most effective household-level intervention was found to be POU filters in combination with safe water storage. According to the authors, however, there is still a beneficial effect of filtering water even when the quality of the sources is accounted for. This finding is in line with similar studies indicating that water, from improved sources, is frequently of poor quality [22].

There are additional reasons why municipal water supply may be of poor quality. One is water transportation from the supplier to the household. Unlike naturally flowing water, which has the capacity to cleanse and purify itself [23], the water pipeline network system may promote habitats for various kinds of microorganisms. With few exceptions, water is run through the pipes under relatively high pressure to counter pipe contamination [24]. It has been argued, although not without contention, that such unnatural compression disrupts the water's natural structure and, consequently, impairs some of its functions, for example the ability to absorb and transport nutrients (*e.g* [25, 26].). According to Davidson, Lauritzen, and Seneff [27], there is significant neglection of the role natural water structure plays in health. The authors propose an alternative framework of disease etiology that places water at the center of causation: When exogenous interfacial water stress disrupts the biological water between and within cells, this gives rise to the pathological macromolecular changes. Such stressors may include additional processing techniques for water disinfection (*e.g.* chlorine or ozone) or supplementation (*e.g.* fluoride). In fact, despite the many reasons why such processing techniques are used, there is critical literature putting forward arguments against their use [28-30].

Less than optimal household water quality may, thus, have potential adverse effects over time [31-33]. Whilst, in theory, tap water is inferior to natural water sources (*e.g.*, mountain or spring water), many natural water sources are no longer safe, even in countries with high regulatory standards [34, 35]. This is why commercial filter systems offer different types of purification processes to produce water that mimics untainted, naturally occurring water. Such treatments that effectively remove chemical contaminants from drinking water have been demonstrated in a critical review of the data on the effectiveness of POU drinking water treatment technologies in the US [36]. However, in the vast majority of the cases, their effectiveness *in actual use* is not investigated. Hence, there is a lack of empirical evidence of how water purification translates to the progression or regression of health symptoms. Moreover, certification usually involves traditional contaminants but does not include novel carcinogens, new industrial and agricultural chemicals, pharmaceuticals, or cosmetics. Evidently, there is a need to test POU water treatment devices with regard to health benefit claims.

In this study, an in-home water filter system (AcalaQuell® Swing) was tested with respect to its ability to mitigate health complaints. The filter is a multi-layered, non-electrical, and non-pressurized system using the ReNaWa® (renaturalization of water) technology to purify tap water and to restore its natural molecular structure. Multiple microbiological laboratory analyses certify the system's capacity to remove up to 99% of potentially toxic substances. To date, however, the device's health benefits have not been tested in a controlled study involving humans. Therefore, a field study was conducted using a pre-clinical sample with a medical history of chronic physical ailments. This study aimed at answering two questions: (1) Does the use of the filter system reduce self-reported health issues, and (2) what are the specific treatment effects?

## 2. MATERIALS AND METHODS

### 2.1. Sample

A total of thirty-six individuals were enrolled in the study *via* newspaper advertisements from which N = 20 subjects (13 women, 7 men) were eligible for the study. Excluded individuals either did not meet the inclusion criteria (*i.e.*, their primary physical complaints did not involve cardiovascular, gastrointestinal or fatigue symptoms; n = 8) or one of the following exclusion criteria applied: (1) complaints did not prevail for at least three months (n = 5), (2) persons were treated for a serious illness that required current medical treatment (n = 3). The inclusion criteria were derived from anecdotal evidence, *i.e.*, from experiences of users regularly employing the device. On average, participants had suffered from their medical condition for eleven months, and sixty percent (n = 12) had previously received medical treatment, either conventionally (n = 7) or with alternative therapies (n = 5). From those medically treated, nine individuals had been diagnosed with idiopathic or psychosomatic symptomatology. Participants were fully briefed about the purpose of the study and provided written informed consent. Participation was remunerated with € 30.

The mean age of the sample was 39.4 years (18-65 years). The mean weight was 69.8 kg (body mass index of 23). At the onset of the study, eleven participants suffered from gastrointestinal symptoms (*e.g.*, constipation, flatulence, abdominal pain, bloating), n = 6 reported exhaustion (*e.g.*, fatigue, weariness, sleep disorders), and n = 3 complained about cardiovascular symptoms (*e.g.,* arrhythmia, tachycardia, heart pressure).

## 2.2. Questionnaires

### *2.2.1. Physical Complaints Form*

Physical complaints were assessed with the revised Freiburg Complaint Form (Freiburger Beschwerdenliste, FBL-R). The FBL-R is a German questionnaire that has been used frequently in psychosomatics, clinical diagnostics, and epidemiological research for over two decades [37]. It is comprised of nine medical scales (burden syndromes). Each scale consists of eight items (with the exception of the scale "fatigue" which has seven items). For the purpose of the study, and in alignment with the theoretical construction of the questionnaire, the response format of some of the items was modified such that the anchors required the respondents to rate the intensity of their complaints rather than the frequency of symptoms ("very strong", "strong", "medium", "hardly", "practically not"). The nine scales pertain to the following medical dimensions:

(1) General Wellbeing, *e.g.*, episodes of headache, hypersensitivity, and lack of appetite.

(2) Fatigue, *e.g.*, weariness, lack of sleep, and exhaustion.

(3) Heart and Circulation, *e.g.*, irregular heart activity, shortness of breath, or heart pain.

(4) Stomach and Intestines, *e.g.*, flatulence, constipation, or abdominal pain.

(5) Irritable Head and Neck Syndrome, *e.g.*, difficulty of swallowing, sore throat, sneezing, or coughing (without a cold).

(6) Strain, *e.g.*, cold hands, sweating, involuntary twitching of muscles, shakiness.

(7) Emotional Reactivity, *e.g.*, responsiveness to stress or tension (*e.g.*, palpitations, blushes).

(8) Pain, *e.g.*, musculoskeletal discomfort and pain in the neck, the shoulders, or lower back.

(9) Sensitivity, *e.g.*, over-susceptibility to bright light or colors, loud noises, and smells.

The internal consistency of the scales is between 0.73 (General Wellbeing) and 0.90 (Heart and Circulation). A number of additional items assess the medical history as well as the current level of stress ("low" through "very high", five anchors), and the self-perceived health status ("poor" through "very good", five anchors").

In accordance with the objective of the study and the inclusion criteria, the scales (2)-(4) were deemed most relevant to assess the treatment effects. However, given that most participants primarily suffered from one predominant medical condition, an individual complaint index was constructed representing a person's prevalent ailment. Additionally, all scales were analyzed to map improvements for multiple disorders (global scores), but it was expected that any potential effects would be mitigated because of the heterogeneity of individual symptoms. Thus, this latter analysis was mainly considered for exploratory purposes.

### *2.2.2. Cognitive and Mental Resiliency Checklist (CMR--CL)*

The CMR-CL comprises of 20 items assessing the degree to which a person is able to withstand physical and mental stress, to stay focused and to remain affectively balanced. The checklist consists of four scales of five items each (item format: "not at all", "rather not", "somehow", "very much"). Some of the items are negatively formulated. The subscale "Psychological Stress" (Cronbach $\alpha = 0.78$) assesses mental tension, inner restlessness, and over-pondering (example: "I am unable to stop ruminating"). The subscale "Physical Stress" (Cronbach $\alpha = 0.81$) assesses susceptibility to physical impairments (example: "I feel vital and energetic"). The subscale "Cognitive Performance" (Cronbach $\alpha = 0.77$) gauges the lack of concentration, distraction, and effort (example: "I have a hard time blocking distractions"). The subscale "Affectivity" (Cronbach $\alpha = 0.82$) measures the balance of positive and negative moods, affects, and emotions. High CMR-CL scores reflect higher cognitive and mental resiliency (Schneider, unpublished manuscript).

### *2.2.3. Expectancy*

Prior to the control week (consumption of tap water) and the intervention week (filtered tap water), participants were asked to rate the effect of the water consumption on their health on a five-point Likert Scale with the anchors "1 = no effect", "2 = small effect", "3 = moderate effect", "4 = strong effect", and "5 = very strong effect". This variable was tested for non-specific (psychological) effects and was used as a possible covariate for the main analyses.

## 2.3. Treatment/Intervention

### *2.3.1. Standard Control (Tap Water)*

All participants underwent a control period during the first three weeks. According to the recommendations of the German Society for Nutrition (DGE), they consumed 35 ml of tap water per kg of body weight per day. The amount of water had to be consumed in small portions throughout the day. All individuals drank from the same regional water supplier. Beyond the required amount of water intake, participants were free to consume additional beverages if they so wished. After the first three weeks, participants returned to their usual drinking habits for one week.

### *2.3.2. Intervention (Filtered Water)*

In weeks five to seven, participants consumed the same amount of tap water. However, before consumption, the water was filtered with the AcalaQuell® Swing filter. The device is a jug sized container consisting of a refill unit of 1 liter, a containing unit of 1.3 liters, a pre-filter-unit (microsponge), and a filter cartridge. The filter does not use pressure but instead allows the water to work its way through the filter chambers. First, the water permeates a 1 µm pore sized microsponge impenetrable to dust, rust, microplastic, or other floating particles. Next, it enters the filter cartridge consisting of three different compartments. In the first, an ion exchanger reduces lime, nitrate, and heavy metals. In the second, high-tech activated carbon removes additional potentially harmful substances, like pesticides, heavy metals, or drug residues. In the third, several materials like ceramic-fired tourmaline, calcium, magnesium, magnets, and quartz sand mineralize, structuralize and mildly alkalize the water. The water filter has been tested by several independent German microbiological laboratories. It has been certified to reduce pesticides (*e.g.*, dichlorbenzamide; > 99%), e.coli bacteria (100%), heavy metals (*e.g.* quicksilver; > 96%), light and semi-metals (*e.g.* aluminum, arsenic; > 80%), pharmaceutics (*e.g.* ibuprofen, benzafibrate; > 99%), polycyclic aromatic hydrocarbons (*e.g.* benzofluoranthene; > 99%), trihalogen methanes (> 99%), and total organic carbon (> 64%).

### 2.4. Study Design and Procedure

The study's design was a controlled, prospective, within group documentation study. The device was not tested against a placebo filter system but instead against a natural history control phase. This was done to reduce both error variance and sample size, which, in a field study of this kind (*i.e.*, two experimental periods), would have required four times more subjects using a between design. More importantly, although placebo controls are the gold standard in clinical trials, they only determine *placebo response* rates (confounding of placebo effects and other unspecific effects like remission, regression, natural course of illness, *etc.*). Testing against a natural history control allows for such confounded unspecific effects to be accounted for. Participants were invited individually. In the first visit, the experimenter explained the rationale of the study, the measurement protocol, and the measuring instruments. Also, participants rated their expectations of the water intake on their health status. Data collection started on a Monday morning and ended on Sunday night of the third week. In the fourth week, participants visited the second time during which the handling of the water filter was explained, the completed questionnaires were collected, and the new ones were handed out. Additionally, participants rated their expectations about the filtered water on their health. At the end of the experiment (week 8), the third visit ensued, where the experimenter received the remaining questionnaires and remunerated the participants.

### 2.5. Data Analysis

In alignment with meta-analytical practice [38], and to avoid pseudo evidence associated with the use of NHST (cf [39-41].], effect sizes and confidence intervals were calculated. Specifically, mean comparisons were computed according to Cohen's d effect size [42]. Confidence intervals (95%) were calculated to estimate the boundaries of the effects [43]. To assess differential effects, the difference in scores of the conditions (post-treatment minus baseline) were compared.

## 3. RESULTS

### 3.1. Expectancy

Overall, participants did not expect standardized water intake to exert any noteworthy effect on their health. On average, the effects were low and identical for both conditions ($Mean_{Control} \pm SD = 1.9 \pm 0.4$ vs. $Mean_{Acala} \pm SD = 1.8 \pm 0.7$; d = 0.2, CI: -0.4 < d < 0.8). Due to the insignificance of this variable, it was not considered as a covariate in the analyses.

### 3.2. Water Consumption

On average, participants' usual beverage intake was 1970 ml per day, with the following predominant fluid sources: tap water (n = 8), mineral water (n = 7), juice (n = 3), and tea (n = 2). During the study, the required daily mean intake of water was 2450 ml. Thus, participants drank considerably more water during the study period than fluids in general on a usual daily basis (d = 0.9; CI: 0.3 < d < 1.6).

### 3.3. Physical Complaints

Table **1** shows the individual complaint scores at the four time points. The average physical complaint levels remained constant over the first three measurements. Neither the higher water consumption during the study nor other potentially relevant confounds (*e.g.*, symptom remissions) had an impact on participants' health status. After daily consumption of filtered water, individual complaints decreased substantially (cf. Fig. **1**). The effect was large (d = 1.4; CI: 0.7 < d < 2) and corresponded to a symptom reduction of about 26%. On average, the physical complaints decreased from "medium to strong" to "hardly to medium". When comparing the global scores for FBL-R, the differences were much smaller. Moreover, they represented zero effects because of the positive and negative confidence interval boundaries (d = 0.2 - 0.6, CI: -0.5 < d < 1). However, for the dimension "Fatigue", a large effect was found (d = 0.9, CI: 0.2 < d < 1.5), which was due to this symptom prevalence in the sample.

### 3.4. Cognitive and Mental Resiliency

The results for the analyses of the cognitive and mental resiliency scales are provided in Table **2**. For all four scales, the differential effects were large and practically identical (mental stress, cognitive performance, affectivity: d = 0.9; CI: 0.3 < d < 1.6, physical stress: d = 0.8; CI: 0.2 < d < 1.5). The effect for the total scale scores was d = 1.0; CI: 0.4 < d < 1.6). The effects were in part due to the tendency of the scale values to somewhat decline during the control condition. Hence, the positive effects of the filtered water on physical and mental stress, mental focus, and affective balance were not solely due to a net improvement. However, the relative improvements were nevertheless obvious. At the end of the intervention phase, resiliency to psychic stress was increased by 42%, resilience to physical stress by 15%, cognitive performance by 11%, and affectivity by 25%.

**Table 1. Means and standard deviations of individual and global complaint burden**

| | Tap Water | | AcalaQuell® Water | |
|---|---|---|---|---|
| | **Day 1** | **Day 21** | **Day 29** | **Day 49** |
| Individual Symptoms | 25.7 (4.6) † | 25.6 (5.6) | 25.3 (4.9) | 18.7 (3.7) |
| Fatigue a | 24.9 (5) | 23.1 (6.2) | 22.5 (6.5) | 16.2 (3.6) |
| Heart/Circulation b | 14.3 (8.3) | 13.5 (8.6) | 13.4 (8.2) | 10.3 (3.9) |
| General Wellbeing b | 24.3 (5.9) | 23.3 (6) | 22.4 (5.4) | 19 (4.7) |
| Stomach/Intestines b | 21.3 (6.8) | 20.3 (7.7) | 19.5 (6.7) | 15.1 (4.7) |
| Irritable Head/Neck Symptoms b | 18.1 (5.5) | 17.3 (7.5) | 14.4 (5.9) | 14.8 (5.2) |
| Strain b | 15.6 (4) | 15.2 (5) | 15 (5.3) | 12.3 (3.5) |
| Emotional Reactivity b | 23.8 (6.2) | 22.6 (6.8) | 22.6 (7) | 19.8 (6.5) |
| Pain b | 20.6 (6) | 19.3 (5.8) | 18.4 (5.9) | 15.2 (4) |
| Sensitivity b | 23.8 (7.8) | 23.1 (7.8) b | 22.8 (7.3) | 21.5 (73) |

† rounded values; a: range = 7-35; b: range = 8-40

**Table 2. Means and standard deviations of the Cognitive and Mental Resiliency scales.**

| | Tap Water | | AcalaQuell® Water | |
|---|---|---|---|---|
| | **Day 1** | **Day 21** | **Day 29** | **Day 49** |
| Resiliency to Mental Stress a | 10.3 (4.8) † | 9.7 (3.7) | 9 (3) | 12.8 (3.3) |
| Resiliency to Physical Stress | 12.3 (4.5) | 11.6 (4) | 11.2 (4.2) | 13.9 (2.4) |
| Cognitive Performance | 13.9 (3.7) | 11.7 (3.4) | 12.3 (3) | 13.7 (1.7) |
| Affectvity | 12.7 (4.8) | 11.3 (4.2) | 11 (4.1) | 13.8 (3.3) |

† rounded values; a range = 5-20; higher scores indicate higher resiliency.

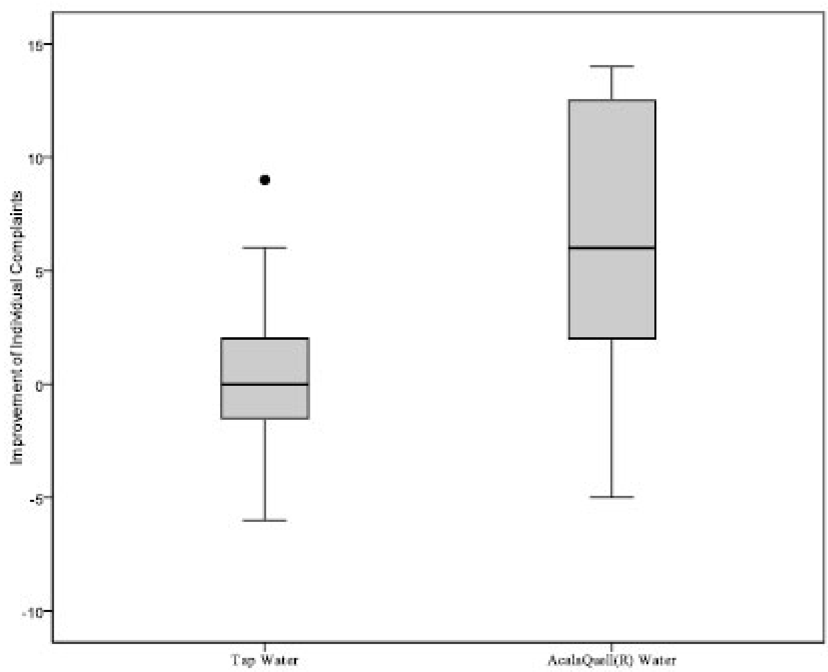


**Fig. (1).** Boxplot for the individual physical complaint improvements (scale values). The calculation for the effect sizes without the outlier yielded an identical result (d = 1.4).

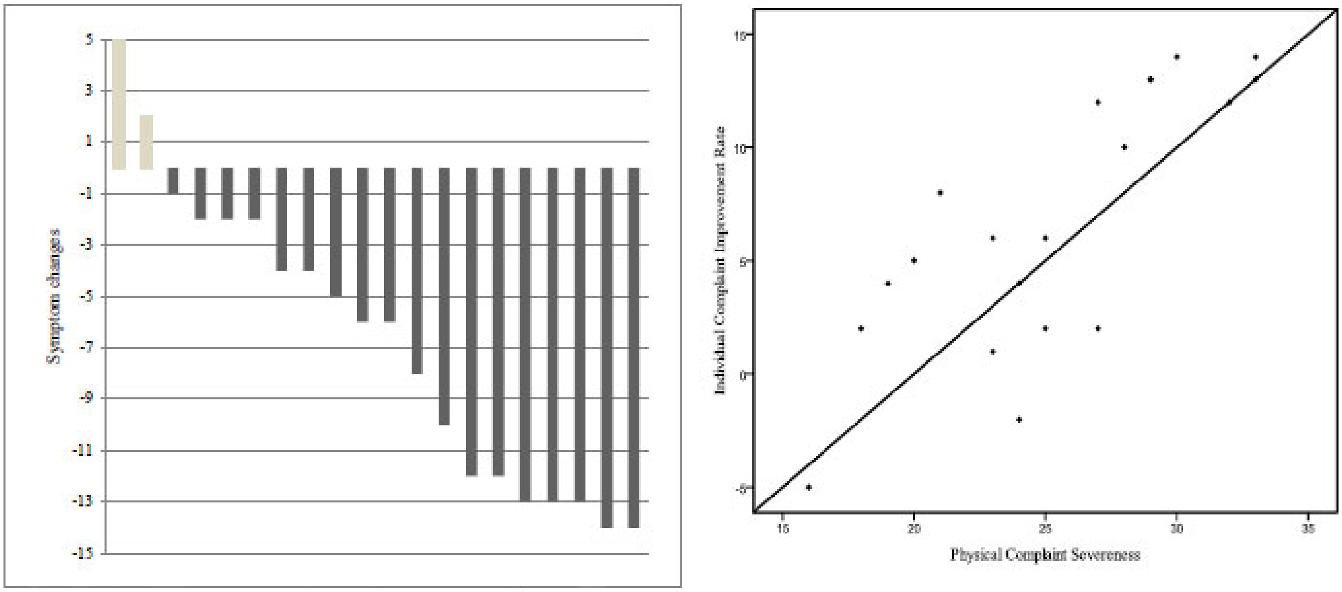


**Fig. (2. a).** Individual changes of physical complaints after regular daily consumption of filtered water for three weeks; **2b** Relationship between complaint severeness and symptom reduction; Symptom reduction: scale differences (pre minus post); white dot: n = 2

### 3.5. Responding

Generally, effectiveness testing may be biased in that group averages do not reveal, and sometimes, even conceal information about individual benefits of an intervention. Thus, the data were inspected with regard to individual improvement rates. Fig. **2a** depicts the absolute individual differences between the two conditions. Two participants experienced a slight worsening of symptoms. For the remaining 90 percent, the positive changes were between 4 to 47 percent, with n = 12 individuals (60 percent) showing an improvement of 20 percent and larger. To test whether symptom severity and symptom improvement were associated, the sample was split in half with the median separating individuals with little and strong physical complaints at the onset of the intervention (day 29). Those suffering from a higher complaint burden (n = 11) experienced more symptom relief than those with a lower burden (n = 9), with the difference between both being large ($d_{Cohen} = 1.7$; CI: $0.7 < d < 2.8$). This finding was corroborated by a strong correlational effect between symptom relief and symptom burden of r = 0.8 (d = 2.7; see fig. **2b**).

### 3.6. Life situation

In order to assess whether and to what extent participants' current life situation had an influence on the results, their ratings were subjected to further analysis. It showed that the stress level remained constant during the time the study was conducted. On a scale of 1 (low) to 5 (very strong), stress was relatively high at all test intervals (score of 3.5 out of 5). The largest difference of 0.2 scale points was statistically negligible ($d < 0.2$). In contrast, and in accordance with the results of the main analyses, participants rated their health status higher at the end of the study (3.2/5) than at the onset (2.3/5). This difference was large (d = 0.8; CI: $0.2 < d < 1.5$) and indicated that the reduction of physical complaints was not due to an artifactual influence of stress reduction. Moreover, it was in alignment with the notion that individuals coped with stress more efficiently, given that their mental and cognitive resiliency increased in the intervention condition. This was corroborated by large correlational effects between individual symptom decline and cognitive performance (r = 0.6/d = 1.6), affectivity (r = 0.8/d = 2.6), resiliency to mental stress (r = 0.7/1.9), and resiliency to physical stress r = 0.8/d = 2.6).

## 4. DISCUSSION

The aim of this study was to determine the effectiveness of the in-home water filter system AcalaQuell® in mitigating health complaints. The results showed that regular intake of a standardized amount of filtered water improved participants' self-reported health. The effects also encompassed psychological factors like mental focus, affectivity, and the ability to deal with physical and mental stress. These findings were not according to the expectations, as there was an increase in water intake, reduction of life stress, and spontaneous symptom remission. The decline in physical complaints corresponded to more than one standard deviation. The fact that the vast majority of the sample showed a marked improvement of their complaints after three weeks was surprising given the relatively high burden at the onset (approximately 70 percent of the score maximum) and the prevalence of the complaints of at least three months. Another important finding was that the AcalaQuell® water specifically affected different physiological systems (*i.e.* digestive, cardiovascular, and nervous), the benefits being stronger with the greater the health impairment of the individual.

This study did not investigate physiological mechanisms, but the findings were in alignment with the laboratory tests showing that the filter improves tap water quality, which, in principle, should be beneficial to health. However, whether the reduction of potentially harmful toxins was causative for symptom relief is unclear, but the water appeared to have altered functional properties, *e.g.*, increased bio-activity, which improved digestion, circulation, and brain functions. If these effects were mediated by an altered (*i.e.* hexagonal) molecular structure is beyond the scope of this paper. In general, there is only limited evidence of the physiological activity of hexagonal water intake in the prevention and treatment of diseases. The few available studies, however, indicate that magnetized water may have the capacity to prevent, for instance, fatigue by increasing cell membrane permeability, to protect against blood and liver DNA damages, or to improve glucose metabolism and liver function [44, 45].

There are several open questions this study could not address.

(1) Whether participants actually consumed the required amount of water could not be controlled. Yet, it seemed unlikely that participants systematically changed their drinking patterns to produce a certain outcome. With regard to their normal drinking behavior, they drank more during the study, but the increase in water intake alone was not associated with fewer complaints. Interestingly, a recent national cohort study was unable to detect an association between higher total and plain water intake and lower health risks [46]. Hence, the quantity of water appears less instrumental in causing health improvements. Instead, it is its quality that produces effects like the ones that were observed in this study.

(2) The exact etiology of symptom reduction is unknown and future studies should involve clinical diagnoses. This would require medical anamnesis and catamnesis, and, preferably, study arms involving other forms of treatment (*e.g.* specific medical therapies), as well as several follow-ups over a longer period of time. In this study, the effect already showed after three weeks, but it would be interesting to determine if, how long, and to what extent regular filter water intake is able to reverse ailments, especially in a clinical sample.

(3) Future investigations should also monitor the source and quality of the water to draw firmer conclusions about the relationship between the filtering process and health. Water quality is dependent on many factors, and, when tested under real life conditions, it may be subjected to various influences. For instance, in this study, some participants observed a yellow discoloration of the microsponge after a few days of filter use. This was indicative of old water pipe systems emitting rust, copper, manganese, soil, and/or vermin residue. Hence, controls of water quality cannot be restricted to the supplier or the sewer system, but instead must involve consideration of POU.

(4) Participants' knowledge of the type of treatment did not increase their expectations of the effect of filtered water. Although this may appear counter-intuitive, it is in alignment with the finding that expectations are shaped either by means of experimenter suggestions and/or by treatment experience [47], which was not the case in this study. The magnitude of the effects observed suggested that the treatment was not ascribable to non-specific within group changes. Nonetheless, to investigate placebo or nocebo effects, which are often associated with many medical conditions (*e.g.*, irritable bowel syndrome, cardiovascular diseases, affective disorders), future studies should investigate the extent to which they contribute to the overall treatment effect [48].

## CONCLUSION

This study is the first to show that the AcalaQuell® Swing water filter system effectively reduces health complaints. The effects on gastrointestinal, cardiovascular, and fatigue ailments as well as mental resiliency are large and appear after three weeks of regular daily water intake using this system.

## STANDARDS OF REPORTING

The study was run according to the Ethical Principles for Medical Research Involving Human Subjects (World Medical Association) and the CONSORT for nonpharmacologic treatment recommendations.

## ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

The study was run according to the Ethical Principles for Medical Research Involving Human Subjects (World Medical Association) and the CONSORT for nonpharmacologic treatment recommendations [49]. The study protocol met the criteria for an exemption from ethical committee approval according to the regulations outlined by the German Ethics Council involving non-harmful agents.

## HUMAN AND ANIMAL RIGHTS

No animals/humans were used for studies that are the basis of this research.

## CONSENT FOR PUBLICATION

Participants were fully briefed about the purpose of the study and provided written informed consent. Participation was remunerated with € 30.

## AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## FUNDING

The study was funded by the company manufacturing the water filter (Acala Inc., Germany).

## CONFLICT OF INTEREST

To make sure that the principal investigator was not biased, he did not interfere with the actual treatments and had no contact with the participants. Instead, an independent experimenter ran the study. Furthermore, all collected data were initially blinded as to the group allocation and only unblinded after the analyses were performed.


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