Revised Reference Values for Potassium Intake

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Keywords

Potassium · Nutrient intake · Reference value

Abstract

Background: The nutrition societies of Germany, Austria and Switzerland have revised the reference values for potassium intake in January 2017. **Methods:** For adults, the estimated value was based on the 24-h urinary potassium excretion and on preventive considerations regarding hypertension and stroke. The estimated values for children and adolescents were extrapolated from the adult estimated value considering differences in body mass. For infants aged 0 to under 4 months, the estimated value was set based on the potassium intake via breast milk. From this reference value, the estimated value for infants aged 4 to under 12 months was also derived by extrapolation. The estimated value for lactating women takes into account the potassium loss via breast milk. **Results:** The estimated values for potassium intake are set at 400 mg/day for breastfed infants aged 0 to under 4 months, 600 mg/day for infants aged 4 to under 12 months, 1,100–4,000 mg/day for children and adolescents, 4,000 mg/day for adults and pregnant women and 4,400 mg/day for lactating women. **Conclusions:** The con-

sumption of potassium-rich foods should be generally increased. Supplemental intake beyond the estimated values has no health benefit and is therefore not recommended.

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Introduction

The D-A-CH ‘reference values for nutrient intake’ [1] are jointly issued by the nutrition societies of Germany, Austria and Switzerland (the abbreviation D-A-CH arises from the initial letters of the common country identification for the countries Germany [D], Austria [A] and Switzerland [CH]). Previously, the ‘reference values for nutrient intake’ were revised for vitamin D [2], calcium [3], folate [4], vitamin C [5], energy [6], selenium [7], thiamin, riboflavin and niacin [8]. The revised reference values for potassium were published in German in January 2017 [1].

Quantitatively, potassium is the main electrolyte in the intracellular space where it is present as water-soluble potassium ion (K⁺) and serves to maintain osmotic pressure, electrolyte homeostasis and acid-base bal-

ance [9]. By maintaining a high intracellular potassium concentration, the Na^+/K^+ -ATPase generates a membrane potential. Control of this electrochemical gradient is essential for the transmission of neural impulses and thus for muscle contraction, heart function and blood pressure regulation [10, 11]. Moreover, potassium is a cofactor of several enzymes involved in protein and glycogen synthesis and plays therefore a crucial role in growth [9, 10].

Criteria to Assess Potassium Supply

Due to potassium homeostasis, plasma concentration of potassium is not suitable to provide information on potassium intake (or status). Instead, the measurement of 24-h urinary potassium excretion is considered the gold standard method for assessment of potassium intake [12–14]. However, 24-h urine collections are complex and require a high level of compliance. To determine potassium intake in an individual using renal potassium excretion, several 24-h urine samples would be required. Therefore, this method is of limited suitability for large population studies. Thus, in order to assess the potassium intake of the general population, 24-h potassium excretion is often estimated based on spot urinary potassium concentrations. However, due to the possible over- or underestimation of potassium excretion, spot urine samples provide relatively inaccurate estimates of potassium intake in individuals [15–17].

Derivation of the Reference Values for Potassium Intake

Adults

There is no experimental data on the potassium requirement in adults. It is therefore not possible to set an average requirement and the reference value for potassium intake is set as estimated value. The potassium intake observed in men and women in Germany is used as a basis to derive the estimated value for potassium intake for adults.

Current data on potassium excretion in spot urine is available from the German Health Interview and Examination Survey for Adults (DEGS1; 2008–2011), which provides nationally representative health data of 7,988 adults aged between 18 and 79 years living in Germany [18]. Thus, taking into account a creatinine correction

factor, the dietary intake of potassium can be estimated [18, 19]. In addition, the urinary potassium excretion has to be corrected by the absorption and the excretion rate of potassium. For this, a conversion factor of 1.3 was chosen based on 2 studies [13, 20] and by following the approach of the World Health Organization (WHO) [21] and the European Food Safety Authority (EFSA) [17]. This results in an estimated median potassium intake of approximately 3,900 mg/day for women (5th [P5] to 95th percentiles [P95]: 1,800–8,000 mg/day) and approximately 4,300 mg/day for men (P5–P95: 2,000–8,000 mg/day).

Due to the uncertainty of potassium excretion measurement based on spot urine sample data from DEGS1, additional preventive aspects regarding hypertension and stroke are taken into account for deriving the reference value for adults.

There is evidence for an association between high potassium intake (intake from supplements and from foods) and prevention of hypertension [22, 23]. A meta-analysis by the WHO [24]¹ of 21 randomised controlled intervention studies reported a reduction in systolic blood pressure of 3.5 mm Hg (95% CI 1.8–5.2) and in diastolic blood pressure of 2.0 mm Hg (95% CI 0.9–3.1) at increased potassium intake, which has been determined by 24-h urinary potassium excretion. The strongest association was observed at a potassium intake of 3,500–4,700 mg/day. The meta-analysis included 16 studies with hypertensive patients (blood pressure $\geq 140/90$ mm Hg), 3 with normotensive subjects and 2 with both hyper- and normotensive subjects. Subgroup analyses demonstrated significant blood pressure-lowering effects in hypertensive patients, while there was no effect on systolic and diastolic blood pressure in normotensive subjects [24]. In general, the antihypertensive effect of potassium is greater at a sodium intake exceeding 4,000 mg/day than at a sodium intake of 2,000–4,000 mg/day [24, 27].

In a prospective cohort study that was published after the WHO meta-analysis [28], a potassium intake of less than 3,500 mg/day was associated with higher risk of hypertension than a potassium intake of more than 3,500 mg/day in 5,511 Dutch normotensive subjects (part of the PREVEND study). Potassium intake in this study was estimated from several 24-h urinary collections.

Furthermore, evidence for an association between high potassium intake and stroke prevention has been

¹ The results of the systematic reviews by the WHO [24–26] were also published by Aburto et al. [21].

reported in several studies, including a pooled analysis of cohort studies [29], an analysis of the Nurses' Health Study I and II [30], and the Women's Health Initiative Study [31]. The association appears to be stronger in normotensive than in hypertensive individuals [31]. The WHO² meta-analysis of cohort studies [25], which included studies in normotensive and hypertensive subjects, reported that high potassium intake was associated with reduced risk of stroke. The strongest association was observed at a potassium intake of 3,500–4,700 mg/day.

These data on potassium intake and risk of hypertension and stroke indicates that the effect in the general population is largest at a potassium intake of 3,500–4,700 mg/day. Potassium intake in the general population estimated by potassium excretion observed in men and women in Germany (from DEGS1) is within this range [19]. Therefore, considering the high prevalence of hypertension in Germany (approximately 30%) [32, 33], the estimated value for potassium intake is set to 4,000 mg/day for men and women (Table 1). It is not considered useful to specify different values for men and women. The value of 4,000 mg/day derived as the estimated value is within the intake range considered having preventive effects (3,500–4,700 mg/day). The exact mean value of this range is not indicated, since it reflects an accuracy that is not available on the basis of the current data.

Children and Adolescents

No experimental data is available on the potassium requirement in children and adolescents. Therefore, the reference values for children and adolescents are based on the values compiled for adults and taking into account differences in body weight and growth factors to consider the requirements for growth (Table 2). Growth factors at the different ages were calculated as the proportional increase in protein requirement for growth relative to the maintenance requirement according to WHO [1, 34]. It is not considered useful to specify different values for boys and girls. When using the age groups and reference body weights, the D-A-CH reference values are based upon [1], the resulting estimated values for potassium intake range from 1,100 mg/day (for 1- to under 4-year-olds) to 4,000 mg/day (for 15- to under 19-year-olds; Tables 1, 2).

² The meta-analysis of cohort studies by the WHO included only the results of studies in the statistical analysis that had not been adjusted for blood pressure values [21, 32].

Table 1. Estimated values for adequate potassium intake

Age	Potassium ^a , mg/day
Infants	
0 to under 4 months	400
4 to under 12 months	600
Children and adolescents	
1 to under 4 years	1,100
4 to under 7 years	1,300
7 to under 10 years	2,000
10 to under 13 years	2,900
13 to under 15 years	3,600
15 to under 19 years	4,000
Adults	
19 to under 25 years	4,000
25 to under 51 years	4,000
51 to under 65 years	4,000
65 years and older	4,000
Pregnant women	4,000
Lactating women	4,400

^a 39.1 mg potassium correspond to 1 mmol potassium.

Infants

The reference values for potassium intake for infants aged 0 to under 4 months were derived from the potassium content of breast milk, which is considered to be the optimal diet for infants [36, 37]. The reference values for infants are therefore estimated values. The average breast milk intake of an exclusively breastfed infant is 750 mL/day [38]. Based on a mean potassium content of breast milk of 50 mg/100 mL within the first 4 months [39–45], the estimated value for potassium intake for breastfed infants aged 0 to under 4 months is set at 400 mg/day (Table 1).

The consumption of breast milk declines along with the introduction of solid foods. Since no data is available from Germany with regard to potassium intake via solid foods, the estimated value for infants aged 0 to under 4 months is used to derive the reference value for infants over 4 months of age (Table 3). Taking into account the differences in average body weight, an estimated value of 600 mg/day for infants aged 4 to under 12 months was derived (Tables 1, 3).

Pregnancy

There is limited potassium accumulation during pregnancy [47, 48]. Thus, the estimated value for potassium intake for pregnant women does not differ from that for non-pregnant women and is set to 4,000 mg/day.

Table 2. Estimated values for potassium intake for children and adolescents taking into account differences in average body weight and growth factors

Age, years	Gender	Reference body weight, kg ^a [1]	Growth factor ^b [1]	Potassium intake considering reference body weight and growth factors, mg/day ^c	Estimated value for potassium intake (rounded), mg/day
1 to under 4	Male	13.9	0.25	983	1,000
	Female	13.2	0.25	1,100	
4 to under 7	Male	20.2	0.06	1,212	1,300
	Female	20.1	0.06	1,421	
7 to under 10	Male	29.3	0.13	1,875	2,000
	Female	28.7	0.13	2,165	
10 to under 13	Male	41.0	0.13	2,624	2,900
	Female	42.1	0.11	3,119	
13 to under 15	Male	55.5	0.10	3,449	3,600
	Female	54.0	0.07	3,845	
15 to under 19	Male	69.2	0.07	4,182	4,000
	Female	59.5	0.02	4,057	

^a The reference values for body weight correspond to the median body weight determined in the German Health Interview and Examination Survey for Children and Adolescents in Germany (KiGGS; 2003–2006) [35]. In each case, the values reflect the mid-point of the respective age range.

^b Growth factors at the different ages were calculated as the proportional increase in protein requirement for growth relative to the maintenance requirement according to the WHO [1, 34].

^c Calculated from: $\text{estimated value}_{\text{adults}} \times (\text{reference body weight}_{\text{children/adolescents}} / \text{reference body weight}_{\text{adults}}) \times (1 + \text{growth factor})$. Estimated value_{adults}: 4,000 mg/day (Table 1). Reference body weight_{adults} (age group 25 to under 51 years): men 70.7 kg, women 60.0 kg [1].

Table 3. Estimated values for potassium intake for infants aged 4 to under 12 months

Age, months	Gender	Reference body weight, kg ^a [1]	Potassium intake considering reference body weights ^b , mg/day	Estimated value for potassium intake (rounded), mg/day
4 to under 12	Male	8.6	614	600
	Female	7.9	620	

^a The reference values for body weight correspond to the median body weight of the WHO child growth standards [46] for the age of 8 months.

^b Calculated from: $\text{estimated value}_{0-4 \text{ months}} \times (\text{reference body weight}_{4-12 \text{ months}} / \text{reference body weight}_{0-4 \text{ months}})$. Estimated value_{0-4 months}: 400 mg/day (Table 1). Reference body weight_{0-4 months}: male 5.6 kg; female 5.1 kg [1].

Lactation

The potassium requirement in women is increased during lactation due to the amount that is secreted with breast milk. Approximately 375 mg potassium/day is secreted with breast milk. Considering a

potassium bioavailability of 85% [20, 49], an additional 400 mg potassium/day is required during lactation. Thus, the estimated value for potassium intake for lactating women amounts to 4,400 mg/day (Table 1).

Preventive Aspects

In the following paragraphs, current available data on potassium is outlined in association with other health-related aspects in addition to the ones used for deriving the reference values.

Regarding the prevention of hypertension, there was no significant effect of increased potassium intake on blood pressure in children in the meta-analysis of intervention studies by the WHO [26]. In cohort studies, high potassium intake was associated with an attenuated age-dependent increase in blood pressure in children and adolescent girls [50, 51].

Results regarding the association between potassium intake and risk of cardiovascular diseases are contradictory. There was no significant association between potassium intake and risk of cardiovascular diseases or coronary heart diseases in the WHO meta-analysis [25] of cohort studies in normotensive and hypertensive subjects. Similarly, urinary potassium excretion was not associated with cardiovascular diseases risk in a cohort study that was published after the WHO meta-analysis [14]. In contrast, higher urinary potassium excretion (>3 vs. <1.5 g/day) was associated with significantly lower risk of mortality and cardiovascular diseases in the large international Prospective Urban Rural Epidemiology cohort study [52], which was also published after the WHO meta-analysis [25].

Even though data on the direct effects of potassium intake on cardiovascular disease risk is inconclusive, high potassium intake may indirectly modulate cardiovascular disease risk via its favourable effect on blood pressure [27], as hypertension is one of the main cardiovascular diseases risk factors [11, 53, 54].

Data regarding the association between potassium intake and bone health is contradictory [55–58]. EFSA has recently highlighted that there is a lack of evidence regarding the association between potassium intake and risk of fracture and concludes that data regarding the association between intake of potassium supplements and bone density is inconsistent and thus, the evidence is insufficient [17].

EFSA also investigated the association between potassium intake and risk of kidney stones [17]. Several cohort studies indicate an association between low potassium intake and increased risk of kidney stones [59–61]. However, intervention studies failed to demonstrate an independent effect of potassium intake on the risk of kidney stones [17, 62, 63].

Several prospective cohort studies investigated the association between potassium intake and risk of type 2 diabetes mellitus [64–68]. However, the results are inconsistent and evidence regarding this association is insufficient [17].

Discussion and Conclusion

Based on the measurement of urinary potassium excretion, current data from DEGS1 of women and men in Germany show that the average potassium intake in the general population is 3,900 mg/day in women and 4,300 mg/day in men. For a potassium intake between 3,500 and 4,700 mg/day, there is evidence for a preventive effect on hypertension and stroke. Therefore, considering the high prevalence of hypertension in Germany, the estimated value for potassium intake for adults is set to 4,000 mg/day. Thus, the consumption of unprocessed foods, such as vegetables and fruits, should be generally increased and the consumption of processed foods reduced in order to achieve a diet rich in potassium and low in other ingredients (e.g. salt). This is achievable as part of a balanced, wholesome diet. Supplemental intake beyond the estimated values for potassium intake has no additional health benefit and is therefore not recommended.

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Disclosure Statement

The authors have no conflicts of interest to declare.

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