**Annex**

**S1.** Age- and sex- standardized cut-offs for body mass index (from [36]) and VO2max (from [42,43]) used for the calculation of the HELENA-IR risk score in males.

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| --- | --- | --- | --- |
| **Age**  **(yrs)** | **Overweight**  **(BMI in kg/m2)** | **Obesity**  **(BMI in kg/m2)** | **Low fitness**  **(VO2max)** |
| 10 years | ≥19.8 | ≥23.96 | <37.3 |
| 10 years and 1 month | ≥19.86 | ≥24.06 | <37.3 |
| 10 years and 2 months | ≥19.92 | ≥24.16 | <37.3 |
| 10 years and 3 months | ≥19.97 | ≥24.25 | <37.3 |
| 10 years and 4 months | ≥20.04 | ≥24.35 | <37.3 |
| 10 years and 5 months | ≥20.09 | ≥24.44 | <37.3 |
| 10 years and 6 months | ≥20.15 | ≥24.54 | <37.3 |
| 10 years and 7 months | ≥20.21 | ≥24.63 | <37.3 |
| 10 years and 8 months | ≥20.27 | ≥24.72 | <37.3 |
| 10 years and 9 months | ≥20.33 | ≥24.81 | <37.3 |
| 10 years and 10 months | ≥20.39 | ≥24.9 | <37.3 |
| 10 years and 11 months | ≥20.45 | ≥24.98 | <37.3 |
| 11 years | ≥20.51 | ≥25.07 | <37.3 |
| 11 years and 1 month | ≥20.56 | ≥25.15 | <37.3 |
| 11 years and 2 months | ≥20.62 | ≥25.24 | <37.3 |
| 11 years and 3 months | ≥20.68 | ≥25.32 | <37.3 |
| 11 years and 4 months | ≥20.74 | ≥25.4 | <37.3 |
| 11 years and 5 months | ≥20.79 | ≥25.48 | <37.3 |
| 11 years and 6 months | ≥20.85 | ≥25.56 | <37.3 |
| 11 years and 7 months | ≥20.91 | ≥25.64 | <37.3 |
| 11 years and 8 months | ≥20.97 | ≥25.72 | <37.3 |
| 11 years and 9 months | ≥21.03 | ≥25.79 | <37.3 |
| 11 years and 10 months | ≥21.08 | ≥25.87 | <37.3 |
| 11 years and 11 months | ≥21.14 | ≥25.94 | <37.3 |
| 12 years | ≥21.2 | ≥26.02 | <37 |
| 12 years and 1 month | ≥21.25 | ≥26.09 | <37 |
| 12 years and 2 months | ≥21.31 | ≥26.17 | <37 |
| 12 years and 3 months | ≥21.37 | ≥26.24 | <37 |
| 12 years and 4 months | ≥21.43 | ≥26.31 | <37 |
| 12 years and 5 months | ≥21.49 | ≥26.38 | <37 |
| 12 years and 6 months | ≥21.54 | ≥26.45 | <37 |
| 12 years and 7 months | ≥21.6 | ≥26.52 | <37 |
| 12 years and 8 months | ≥21.66 | ≥26.59 | <37 |
| 12 years and 9 months | ≥21.72 | ≥26.66 | <37 |
| 12 years and 10 months | ≥21.78 | ≥26.73 | <37 |
| 12 years and 11 months | ≥21.83 | ≥26.8 | <37 |
| 13 years | ≥21.89 | ≥26.87 | <36.6 |
| 13 years and 1 month | ≥21.95 | ≥26.94 | <36.6 |
| 13 years and 2 months | ≥22.01 | ≥27 | <36.6 |
| 13 years and 3 months | ≥22.07 | ≥27.07 | <36.6 |
| 13 years and 4 months | ≥22.13 | ≥27.14 | <36.6 |
| 13 years and 5 months | ≥22.19 | ≥27.2 | <36.6 |
| 13 years and 6 months | ≥22.24 | ≥27.26 | <36.6 |
| 13 years and 7 months | ≥22.3 | ≥27.33 | <36.6 |
| 13 years and 8 months | ≥22.36 | ≥27.39 | <36.6 |
| 13 years and 9 months | ≥22.42 | ≥27.46 | <36.6 |
| 13 years and 10 months | ≥22.48 | ≥27.52 | <36.6 |
| 13 years and 11 months | ≥22.54 | ≥27.58 | <36.6 |
| 14 years | ≥22.6 | ≥27.64 | <36.3 |
| 14 years and 1 month | ≥22.66 | ≥27.7 | <36.3 |
| 14 years and 2 months | ≥22.72 | ≥27.76 | <36.3 |
| 14 years and 3 months | ≥22.77 | ≥27.82 | <36.3 |
| 14 years and 4 months | ≥22.83 | ≥27.88 | <36.3 |
| 14 years and 5 months | ≥22.89 | ≥27.94 | <36.3 |
| 14 years and 6 months | ≥22.95 | ≥28 | <36.3 |
| 14 years and 7 months | ≥23 | ≥28.05 | <36.3 |
| 14 years and 8 months | ≥23.06 | ≥28.11 | <36.3 |
| 14 years and 9 months | ≥23.12 | ≥28.16 | <36.3 |
| 14 years and 10 months | ≥23.17 | ≥28.22 | <36.3 |
| 14 years and 11 months | ≥23.23 | ≥28.27 | <36.3 |
| 15 years | ≥23.28 | ≥28.32 | <36 |
| 15 years and 1 month | ≥23.33 | ≥28.37 | <36 |
| 15 years and 2 months | ≥23.39 | ≥28.42 | <36 |
| 15 years and 3 months | ≥23.44 | ≥28.47 | <36 |
| 15 years and 4 months | ≥23.49 | ≥28.52 | <36 |
| 15 years and 5 months | ≥23.54 | ≥28.56 | <36 |
| 15 years and 6 months | ≥23.59 | ≥28.61 | <36 |
| 15 years and 7 months | ≥23.64 | ≥28.66 | <36 |
| 15 years and 8 months | ≥23.69 | ≥28.7 | <36 |
| 15 years and 9 months | ≥23.74 | ≥28.75 | <36 |
| 15 years and 10 months | ≥23.79 | ≥28.8 | <36 |
| 15 years and 11 months | ≥23.84 | ≥28.84 | <36 |
| 16 years | ≥23.89 | ≥28.89 | <35.8 |
| 16 years and 1 month | ≥23.94 | ≥28.93 | <35.8 |
| 16 years and 2 months | ≥23.99 | ≥28.97 | <35.8 |
| 16 years and 3 months | ≥24.04 | ≥29.02 | <35.8 |
| 16 years and 4 months | ≥24.08 | ≥29.06 | <35.8 |
| 16 years and 5 months | ≥24.13 | ≥29.11 | <35.8 |
| 16 years and 6 months | ≥24.18 | ≥29.15 | <35.8 |
| 16 years and 7 months | ≥24.22 | ≥29.2 | <35.8 |
| 16 years and 8 months | ≥24.27 | ≥29.24 | <35.8 |
| 16 years and 9 months | ≥24.32 | ≥29.29 | <35.8 |
| 16 years and 10 months | ≥24.37 | ≥29.34 | <35.8 |
| 16 years and 11 months | ≥24.41 | ≥29.38 | <35.8 |
| 17 years | ≥24.46 | ≥29.43 | <35.7 |
| 17 years and 1 month | ≥24.5 | ≥29.48 | <35.7 |
| 17 years and 2 months | ≥24.55 | ≥29.52 | <35.7 |
| 17 years and 3 months | ≥24.6 | ≥29.57 | <35.7 |
| 17 years and 4 months | ≥24.64 | ≥29.62 | <35.7 |
| 17 years and 5 months | ≥24.69 | ≥29.67 | <35.7 |
| 17 years and 6 months | ≥24.73 | ≥29.71 | <35.7 |
| 17 years and 7 months | ≥24.78 | ≥29.76 | <35.7 |
| 17 years and 8 months | ≥24.82 | ≥29.81 | <35.7 |
| 17 years and 9 months | ≥24.87 | ≥29.86 | <35.7 |
| 17 years and 10 months | ≥24.91 | ≥29.9 | <35.7 |
| 17 years and 11 months | ≥24.96 | ≥29.95 | <35.7 |
| ≥18 years | ≥25 | ≥30 | <35.3 |

**S2.** Age- and sex- standardized cut-offs for body fatness (fat mass index from [38]) and VO2max (from [42,43]) used for the calculation of the HELENA-IR risk score in females

|  |  |  |
| --- | --- | --- |
| **Age**  **(years)** | **Obesity**  **(fat mass index in kg/m2)** | **Low fitness**  **(VO2max)** |
| 10 | ≥7.34 | <37.3 |
| 10.5 | ≥7.6 | <37.3 |
| 11 | ≥7.81 | <37.3 |
| 11.5 | ≥7.94 | <37.3 |
| 12 | ≥8.01 | <37 |
| 12.5 | ≥8.04 | <37 |
| 13 | ≥8.08 | <36.6 |
| 13.5 | ≥8.13 | <36.6 |
| 14 | ≥8.22 | <36.3 |
| 14.5 | ≥8.37 | <36.3 |
| 15 | ≥8.6 | <36 |
| 15.5 | ≥8.89 | <36 |
| 16 | ≥9.21 | <35.8 |
| 16.5 | ≥9.54 | <35.8 |
| 17 | ≥9.88 | <35.7 |
| 18 | ≥9.88 | <35.3 |

**S3.** Overview of the steps needed to calculate the HELENA IR score for males.

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| --- | --- | --- |
| Step | | **Example** |
| 1 | Calculate age in years with precision of one-month | *On September 15th, 2022 an adolescent that was born on January 1st, 2010, will have completed 12 years and 8 months of age.* |
| 2 | Calculate the Body Mass Index (BMI) by dividing adolescent’s weight (in kg) by adolescent’s height (in meters) squared | *The adolescent weighs 50 kg and measures 1.49m in height. Thus his BMI is 22.52 kg/ m2, calculated by dividing 50 with 2.22 (i.e. 1.49x1.49).* |
| 3 | Use the age (Step 1) and BMI (Step 2) to assess if the BMI indicates an adolescent that has overweight or obesity. | *In Table S1, we see that a male adolescent aged 12 years and 8 months has overweight if his BMI is higher than 21.66kg/m2 and obesity if his BMI is higher than 26.59kg/m2. This means that the adolescent of the example with a BMI of 22.52kg/m2 has overweight.* |
| 4 | The school’s physical education instructor or other relevant school health service can regularly perform the 20 m multi-stage fitness test at school/class level and based on it calculate VO2max (using the Leger equation). | *Use the Leger equation [41] to calculate the VO2max. The inputs to the equation are: the speed corresponding to the last stage achieved at the 20m multi-stage fitness test, and the adolescent’s age. This value can be calculated by a physical education expert.*  *For the specific example, we will assume a VO2max of 36 ml/ (kg x min).* |
| 5 | Use the age (Step 1) and VO2 max (Step 4) to assess if the adolescent is in the low fitness zone or not. | *In Table S1, we see that a male adolescent aged 12 years and 8 months has low fitness if his VO2max is less than 37 ml/ (kg x min). Thus the adolescent of this example with a VO2max of 36 ml/ (kg x min) is in the low fitness zone.* |
| 6 | Use the algorithm of Figure 3 to identify if the adolescent is above the 75th percentile and the 95th percentile for HOMA-IR | *The adolescent is above the 95th percentile for HOMA-IR.* |

**S4.** Overview of the steps needed to calculate the HELENA IR score for females.

|  |  |  |
| --- | --- | --- |
| Step | | **Example** |
| 1 | Calculate age in years with precision of month. | *On September 15th, 2022 an adolescent that was born on January 1st, 2010, will be have completed 12 years of age* *and 8 months of age.* |
| 2 | Measure the body fat in kg. This step can be performed by a health professional or even using home scales that have this function. Calculate the Fat Mass Index (FMI) by dividing adolescent’s body fat (in kg) by adolescent’s height (in meters) squared. | *Let’s assume the adolescent weighs 50 kg, measures 1.49m in height. and has 17.65kg of body fat. Thus her FMI is 7.95 kg/ m2, calculated by dividing 17.65 with 2.22 (i.e. 1.49x1.49).* |
| 3 | Use the age (Step 1) and FMI (Step 2) to assess if the adolescent hashas an FMI ≥90th percentile. | *In Table S2, we see that a female adolescent aged 12 years* *and 8 months, is above the 90th percentile if her FMI is higher than 8.04kg/m2. This means that the adolescent of the example with an FMI of 7.95 kg/m2 is below the 90th percentile.* |
| 4 | The school’s physical education instructor or other relevant school health service can regularly perform the 20 m multi-stage fitness test at school/class level and based on it calculate VO2max (using the Leger equation). | *Use the Leger equation [41] to calculate the VO2max. The inputs to the equation are: the speed corresponding to the last stage achieved at the 20m multi-stage fitness test, and the adolescent’s age. This value can be calculated by a physical education expert.*  *For the specific example, we will assume a VO2max of 36 ml/ (kg x min).* |
| 5 | Use the age (Step 1) and VO2 max (Step 4) to assess if the adolescent is in the low fitness zone or not. | *In Table S2, we see that a female adolescent aged 12 years and 8 months has low fitness if her VO2max is less than 37 ml/ (kg x min). Thus the adolescent of this example with a VO2max of 36 ml/ (kg x min) is in the low fitness zone.* |
| 6 | Assess the number of hours the adolescent watches TV on average | *Let’s assume that the adolescent of this example watches on average 2.5 hours of TV per day.* |
| 6 | Use the algorithm of Figure 4 to identify if the adolescent is above the 75th percentile and the 95th percentile for HOMA-IR | *The adolescent is above the 95th percentile for HOMA-IR.* |