The type of relative motion between the bearing surfaces of prosthetic joints is known to strongly influence their wear behaviour. The previously validated 16-station wear simulator of the pin-on-disc type, called RandomPOD, was used to study the wear of a conventional, gamma-sterilized ultra-high molecular weight polyethylene (UHMWPE). The counterface was polished CoCr and the lubricant was diluted calf serum. Two test conditions were compared, random motion/random load and circular translation/static load. With random motion, the accumulated change of the direction of sliding was 2.8 times higher than that with circular translation. The test duration with both test conditions was 880 h. Random motion/random load resulted in a mean wear factor 23% higher than that produced with circular translation/static load. The difference was statistically significant. The wear mechanisms however were similar and in agreement with clinical observations. As earlier studies have shown that the type of load is of secondary importance, the present study confirms the earlier findings that the type of relative motion is tribologically of fundamental importance. In particular, the complex, yet biomechanically realistic non-cyclic motion, represented by the random track, resulted in a wear factor significantly higher than that produced by a fixed slide track shape.
reciprocator driven by a crank. The random load varied from zero to 142 N with an average close to 71 N. The load set value was a smoothed 5 Hz random step signal. The maximum load change rate of the set value signal was limited to 300 N/s. In the random track, the accumulated change of direction of sliding (absolute value of computed increment summed) was 2.8 times that of the circular track with the same sliding distance. In circular translation, the pin translated along a circular track of 10 mm diameter relative to the disc with constant sliding velocity of 15.7 mm/s, and so the direction of sliding relative to the pin changed at a constant rate, \( \pi/\theta \). This was half of that used in the validation study [8] in order to have a sliding velocity equal to the average sliding velocity of the random motion. With circular translation, a constant value of load, 71 N, was applied.

The pins (diameter 9.0 mm, length 12 mm) were conventional GUR 1020 UHMWPE (ISO 5834-1/-2). They were gamma-irradiated by 25–40 kGy in nitrogen, a method used in the sterilisation of prosthetic components. The discs were polished CoCrMo wrought alloy (ISO 5832-12) with a surface roughness \( R_a \) value of 0.01 \( \mu \)m. The contact was flat-on-flat (area 63.6 \( \text{mm}^2 \)). The lubricant was HyClone Alpha Calf Fraction serum SH30212.03, diluted 1:1 with Milli-Q-grade distilled water. The total protein concentration of the lubricant was 20 mg/ml. The RandomPOD has a separate lubricant chamber for each test station, containing 18 ml of lubricant.

A new temperature control system was added to the device. The lubricant chambers were surrounded by circulating cooling water. The control system kept the lubricant temperature at \( 20 \pm 0.5 \) °C with a view to retarding the detrimental denaturation and degradation of serum.

The test duration was 36 days, and the total sliding distance was ca. 50 km. The accumulated change of direction of sliding was \( 1.6 \times 10^8 \) with random motion and \( 0.57 \times 10^8 \) with circular translation. The test was stopped every 6 days for the weighing of the pins. In this way, 6 points were obtained for the determination of the wear rate using linear regression. From this, the wear factor was calculated using the numerically integrated product of the instantaneous load and sliding increment [8], and the density of UHMWPE.

Two consecutive 36 day tests were run, first with random motion/random load and then with circular translation/static load. The same pins were used in both tests. The wear factors were compared with a \( t \)-test. In each reassembly, the position and location of the specimens were randomized (Table 1), and the lubricant chambers were filled with fresh serum.

In addition, two shorter tests of 6 day duration were done with the same specimens to check the following. First, whether the wear factor in the circular translation/static load mode using the 15.7 mm/s sliding velocity differs from that produced by the device with the sliding velocity of 31.4 mm/s used in the earlier study [8]. Second, with random motion/random load, after the
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