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ORIGINAL ARTICLE

# Bone mass density in the normal population of Iran

M. AKBARIAN, F. DAVATCHI, A. SALIMZADEH, F. SHAHRAM, F. GHARIBDOUST, A. NADJI, M. PAJOUHI and A. JAMSHIDI

*Osteoporosis Unit, Rheumatology Research Center, Shariati Hospital, Tehran University for Medical Sciences, Tehran, Iran*

## Abstract

**Background:** Bone mineral density (BMD) of the spine and the femoral neck are accurate indicators of the bone mass and thus useful predictors of fracture risk. Dual energy X-ray absorptiometry (DEXA) is the easiest, yet the most precise and non-invasive technique. The need for a population-specific normative BMD data is vital in preventing mislabelling or misdiagnosis of osteopenia or even osteoporosis.

**Aim:** This study was performed to determine the lumbar vertebral and the proximal femur BMD measured by DEXA in 280 normal Iranian men and women.

**Method:** Subjects were selected randomly from different social economic classes in Tehran. Normal subjects were selected for each decade and both sexes. BMD was measured with a Hologic QDR 1000+ densitometer, for the lumbar spine (L1, L2, L3, L4, L1–L4) and the femoral neck (neck, trochanter, intertrochanter, ward triangle, total). Data were treated by polynomial approximation (3rd degree).

**Results:** In women, the highest BMD recorded was 1.020 g/cm$^2$ for the lumbar spine (mean L1–L4) at the age of 31 years, and 0.832 for the femoral neck at the age of 34. In men, the highest BMD recorded was 0.987 g/cm$^2$ for the lumbar spine (mean L1–L4) at the age of 36, and 0.907 for the femoral neck at the age of 30. The highest BMD in spine was lower in men than women.

**Conclusion:** The BMD of both lumbar spine and femoral neck (in both sexes) was lower in this study than the Hologic standards.

**Key words:** bone mineral density, dual energy X-ray absorptiometry (DEXA), osteoporosis.

## INTRODUCTION

Osteoporosis is one of the critical diseases of the ageing population. Along with heart diseases, stroke, diabetes, and cancer, it is one of the most important disorders encountered in clinical practice all over the world.[1,2] Due to osteoporosis, each year hundreds of thousands of elderly people, especially women, experience fractures of the proximal femur (hip), distal forearm (Colles' fracture), and vertebra.[3,4] Not very long ago, a fracture due to bone fragility or an explicit X-ray was the basis for the diagnosis of osteoporosis. Today, bone mass density (BMD) measurement has become the basis for its diagnosis. A reduction of the T-score of more than 2 standard deviations on BMD was commonly used as diagnostic criterion for osteoporosis, underlying the concept of 'fracture threshold'.[5,6] Today (in concert with a report from the World Health Organization) osteoporosis is defined as a reduction of the T-score of 2.5 or more standard deviations.[7,8] T-score is the 'subject BMD – young normal mean over young normal standard deviation'. The 'young normal' data is composed of reference data for 20–39-year-olds. Recent studies have shown that BMD quantification is predictive of fracture risk.[9] Higher risk of fractures is closely related to the decrease of BMD.[3] Dual energy X-ray absorptiometry

*Correspondence*: F. Davatchi, Rheumatology Research Center, Shariati Hospital, Kargar Avenue, Tehran 14114, Iran.
Email: fddh@davatchi.net

(DEXA), is an excellent, safe, accurate and precise way to measure BMD. It can be used to assess the risk of fracture more accurately than any other way.[9–15] There are reports suggesting that BMD of the spine and femur in the Caucasian population of USA and Europe are very similar.[16–18] Other reports however, indicate the influence of genetic background and geographic variation in different countries.[16,19] The wide interracial variability in bone mass precludes the use of a single normal data. People of African origin have higher bone density and fewer osteoporotic fractures than age- and weight-matched Caucasian populations.[20] Furthermore, Africans reach a higher peak bone mass compared to Caucasians, probably due to a greater bone growth at puberty. Likewise, people of Asian origin are thought to be at increased risk of fractures than other ethnic groups.[20] In addition to the genetic potential, environmental factors also play a significant role in the determination of BMD in single individuals and in people living in specific geographic areas.[20] Therefore, the diagnostic value of bone mass depends on the knowledge of normal data in the same environment and for the same ethnic origin. Deviation from normative values may be used to assess the risk of fracture, and establish the need for therapeutic interventions.

The aim of the present study was to find the normal BMD values of the spine and femur in the Iranian population, and to compare it with the Hologic standard for Caucasians in USA.

## MATERIALS AND METHODS

We measured the BMD of the lumbar spine and the proximal left femur of 280 healthy men and women, aged 10–84 years. The project was approved by the ethics committee of the Rheumatology Research Center (RRC), Tehran University for Medical Sciences. Subjects were selected from different socio-economic classes in Tehran, from 1600 workers of Shariati Hospital and their 5000 relatives. For each decade of age, subjects were allocated a random number. Then for each decade of age and for each sex, 20 normal subjects were selected (140 men and 140 women) according to random numbers. Due to some withdrawals, the final case selection became as shown in Table 1. All subjects were explained about the bone densitometry method and informed consent was obtained from all of them.

The inclusion criteria were the random selected cases. The exclusion criteria were diseases known to decrease BMD and drugs influencing BMD. All cases answered a detailed questionnaire concerning health, diet, use of drugs, menstruation, pregnancies, and lifestyle. Cases using drugs affecting calcium metabolism and those with a disease known to affect the bone metabolism were excluded from the analysis. The final population consisted of 158 women and 122 men.

BMD was determined using the dual energy x-ray absorptiometry method (Hologic QDR-1000+ machine). All BMD measures were taken with the same machine, in one centre, and by the same technician. The measurement sites for the lumbar vertebrae were L1, L2, L3, and L4. For the femur, it was the femoral neck, Ward's triangle, trochanter, and intertrochanter. A mean L1–L4 was calculated for the spine along with a mean total value for the femur. The quality control was measured by Phantom test. The precision of the method was constant (1%).

Data were treated by polynomial approximation (3rd degree). The obtained curves were compared with the standard Hologic curves for Caucasians.

## RESULTS

### Women

In the lumbar spine, the highest BMD recorded was 0.960 g/cm$^2$ for L1, 1.026 g/cm$^2$ for L2, 1.049 g/cm$^2$ for L3, 1.035 g/cm$^2$ for L4, and 1.020 g/cm$^2$ for the mean L1–L4. The highest BMD was reached at the age of 30 for L1 and L2, 31 for L3, 32 for L4, and 31 for L1–L4. Table 2 shows the BMD of the lumbar spine at different ages for women. In the femur, the highest BMD recorded was 0.832 g/cm$^2$ for the femoral neck, 0.680 g/cm$^2$ for the trochanter, 1.088 g/cm$^2$ for the intertrochanter, 0.693 g/cm$^2$ for the Ward's triangle, and 0.936 g/cm$^2$ for the total. The highest BMD was reached at the age of 34 for the femoral neck, 29 for the trochanter, 37 for the intertrochanter, 27 for the Ward's triangle, and 33 for the total. The BMDs of the

**Table 1** The selection of normal subjects

| Age | 10–19 | 20–29 | 30–39 | 40–49 | 50–59 | 60–69 | 70–79 | 80–89 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Female | 17 | 17 | 21 | 36 | 25 | 21 | 15 | 0 | 159 |
| Male | 20 | 18 | 23 | 19 | 24 | 12 | 11 | 1 | 122 |
| Total | 37 | 35 | 44 | 55 | 49 | 33 | 26 | 1 | 280 |

**Table 2** Bone mass density in normal Iranian women, in lumbar spine at different ages

| Age (years) | L1 g/cm$^2$ | L2 g/cm$^2$ | L3 g/cm$^2$ | L4 g/cm$^2$ | L1–L4 g/cm$^2$ | L1–L4 SD |
|---|---|---|---|---|---|---|
| 10 | 0.682 | 0.712 | 0.727 | 0.700 | 0.706 | |
| 15 | 0.795 | 0.838 | 0.851 | 0.825 | 0.829 | 0.15 |
| 20 | 0.892 | 0.945 | 0.960 | 0.935 | 0.935 | 0.08 |
| 25 | 0.944 | 1.005 | 1.022 | 1.001 | 0.996 | 0.06 |
| 30 | 0.960 | 1.026 | 1.048 | 1.032 | 1.019 | 0.09 |
| 35 | 0.947 | 1.016 | 1.043 | 1.033 | 1.013 | 0.07 |
| 40 | 0.913 | 0.983 | 1.017 | 1.013 | 0.944 | 0.15 |
| 45 | 0.865 | 0.937 | 0.976 | 0.978 | 0.944 | 0.15 |
| 50 | 0.812 | 0.885 | 0.929 | 0.936 | 0.896 | 0.12 |
| 55 | 0.760 | 0.836 | 0.883 | 0.894 | 0.849 | 0.14 |
| 60 | 0.718 | 0.799 | 0.845 | 0.859 | 0.811 | 0.08 |
| 65 | 0.692 | 0.782 | 0.824 | 0.839 | 0.791 | 0.14 |
| 70 | 0.691 | 0.794 | 0.828 | 0.840 | 0.795 | 0.15 |
| 75 | 0.722 | 0.843 | 0.863 | 0.871 | 0.831 | 0.17 |

**Table 3** Bone mass density in normal Iranian women, in the femoral head at different ages

| Age (years) | Neck g/cm$^2$ | Neck SD | Trochanter g/cm$^2$ | Inter-Troch g/cm$^2$ | Total g/cm$^2$ | Ward g/cm$^2$ |
|---|---|---|---|---|---|---|
| 10 | 0.655 | | 0.593 | 0.784 | 0.719 | 0.572 |
| 15 | 0.715 | 0.05 | 0.627 | 0.876 | 0.794 | 0.626 |
| 20 | 0.772 | 0.05 | 0.657 | 0.965 | 0.863 | 0.670 |
| 25 | 0.808 | 0.10 | 0.674 | 1.028 | 0.908 | 0.691 |
| 30 | 0.827 | 0.14 | 0.680 | 1.067 | 0.931 | 0.691 |
| 35 | 0.831 | 0.11 | 0.676 | 1.086 | 0.936 | 0.675 |
| 40 | 0.822 | 0.09 | 0.664 | 1.086 | 0.925 | 0.645 |
| 45 | 0.802 | 0.10 | 0.646 | 1.070 | 0.903 | 0.605 |
| 50 | 0.774 | 0.11 | 0.622 | 1.042 | 0.871 | 0.558 |
| 55 | 0.739 | 0.10 | 0.595 | 1.003 | 0.833 | 0.507 |
| 60 | 0.700 | 0.14 | 0.566 | 0.956 | 0.793 | 0.456 |
| 65 | 0.660 | 0.10 | 0.537 | 0.904 | 0.752 | 0.406 |
| 70 | 0.620 | 0.08 | 0.508 | 0.848 | 0.714 | 0.363 |
| 75 | 0.582 | 0.07 | 0.483 | 0.793 | 0.683 | 0.329 |

femur in different ages for women are shown in Table 3.

### Men

In the lumbar spine, the highest BMD recorded was 0.945 g/cm$^2$ for L1, 0.997 g/cm$^2$ for L2, 1.008 g/cm$^2$ for L3, 1.008 g/cm$^2$ for L4, and 0.987 g/cm$^2$ for the L1–L4. The highest BMD was reached at the age of 37 for L1 and L2, 35 for L3, 36 for L4, and 36 for L1–L4. Table 4 shows the BMD of the lumbar spine at different ages for men. In the femur, the highest BMD recorded was 0.907 g/cm$^2$ for the femoral neck, 0.738 g/cm$^2$ for the trochanter, 1.219 g/cm$^2$ for the intertrochanter, 0.714 g/cm$^2$ for the Ward's triangle, and 1.021 g/cm$^2$ for the total. The highest BMD was reached at the age of 30 for the femoral neck, 28 for the trochanter, 34 for the intertrochanter, 23 for the Ward's triangle, and 32 for the total. The BMDs of the femur in different ages for men are shown in Table 5.

## DISCUSSION

The BMD of both lumbar spine and femoral neck in women and in men were lower than the reference range provided by Hologic curves. The difference was more pronounced in lower ages (< 25). This may be due to dietary factors. During the last 20 years the use of dairy products has been low in Iran. However, the comparison of the highest BMD in healthy Iranian people with the Hologic reference showed minor differences

**Table 4** Bone mass density in normal Iranian men, in the lumbar spine at different ages

| Age (years) | L1 g/cm$^2$ | L2 g/cm$^2$ | L3 g/cm$^2$ | L4 g/cm$^2$ | L1–L4 g/cm$^2$ | L1–L4 SD |
|---|---|---|---|---|---|---|
| 10 | 0.582 | 0.615 | 0.639 | 0.646 | 0.621 | |
| 15 | 0.721 | 0.757 | 0.783 | 0.790 | 0.763 | 0.08 |
| 20 | 0.822 | 0.861 | 0.885 | 0.892 | 0.864 | 0.12 |
| 25 | 0.888 | 0.932 | 0.952 | 0.958 | 0.931 | 0.14 |
| 30 | 0.927 | 0.975 | 0.989 | 0.994 | 0.970 | 0.11 |
| 35 | 0.943 | 0.994 | 1.002 | 1.007 | 0.986 | 0.09 |
| 40 | 0.931 | 0.996 | 0.997 | 1.003 | 0.984 | 0.15 |
| 45 | 0.931 | 0.984 | 0.980 | 0.988 | 0.971 | 0.11 |
| 50 | 0.913 | 0.965 | 0.957 | 0.967 | 0.951 | 0.12 |
| 55 | 0.895 | 0.943 | 0.934 | 0.948 | 0.931 | 0.13 |
| 60 | 0.883 | 0.923 | 0.916 | 0.936 | 0.916 | 0.12 |
| 65 | 0.881 | 0.911 | 0.911 | 0.938 | 0.911 | 0.13 |
| 70 | 0.896 | 0.911 | 0.923 | 0.960 | 0.923 | 0.06 |
| 75 | 0.889 | 0.929 | 0.958 | 1.007 | 0.956 | 0.07 |
| 80 | 0.999 | 0.969 | 1.023 | 1.087 | 1.016 | 0.10 |

**Table 5** Bone mass density in normal Iranian men, in the femoral head at different ages

| Age (years) | Neck g/cm$^2$ | Neck SD | Trochanter g/cm$^2$ | Inter-Troch g/cm$^2$ | Total g/cm$^2$ | Ward g/cm$^2$ |
|---|---|---|---|---|---|---|
| 10 | 0.720 | | 0.656 | 0.813 | 0.761 | 0.648 |
| 15 | 0.807 | 0.12 | 0.696 | 0.983 | 0.873 | 0.689 |
| 20 | 0.865 | 0.11 | 0.721 | 1.101 | 0.950 | 0.710 |
| 25 | 0.897 | 0.10 | 0.735 | 1.175 | 0.997 | 0.713 |
| 30 | 0.907 | 0.11 | 0.738 | 1.211 | 1.018 | 0.702 |
| 35 | 0.901 | 0.09 | 0.734 | 1.218 | 1.020 | 0.680 |
| 40 | 0.882 | 0.13 | 0.724 | 1.203 | 1.007 | 0.649 |
| 45 | 0.855 | 0.08 | 0.711 | 1.173 | 0.984 | 0.614 |
| 50 | 0.824 | 0.09 | 0.696 | 1.136 | 0.957 | 0.577 |
| 55 | 0.794 | 0.11 | 0.682 | 1.100 | 0.931 | 0.542 |
| 60 | 0.769 | 0.08 | 0.670 | 1.072 | 0.910 | 0.511 |
| 65 | 0.754 | 0.10 | 0.664 | 1.060 | 0.900 | 0.488 |
| 70 | 0.752 | 0.19 | 0.666 | 1.071 | 0.906 | 0.476 |
| 75 | 0.768 | 0.16 | 0.676 | 1.112 | 0.934 | 0.477 |
| 80 | 0.807 | 0.06 | 0.699 | 1.192 | 0.988 | 0.496 |

(Figs 1–4, Tables 6–9). For the spine, in women, it was 2.5%. The overall mean difference, in women and for the lumbar spine (Fig. 1), was 6.5% (2–21%, CI = 1). For the femoral neck (Fig. 2) the mean difference was 5.4% (2–16%). In men, for the lumbar spine (Fig. 3) the mean difference was 13.8% (2–36%, CI = 1.45) and for the femoral neck (Fig. 4) it was 4.6% (1–14%, CI = 0.96). However, the BMD of the femoral neck in elder men (> 75) was higher than the Hologic standard. The mean difference was 3% at the age of 75 and 10% at the age of 80. This may be attributed to osteoarthritis of the hip joint.

The mean BMD of the lumbar spine in younger people was higher for women than men, especially for the highest BMD recorded. The higher BMD of the spine in women was also seen in a cohort of patients with different inflammatory and non-inflammatory diseases (unpublished pers. obs.). This is contrary to the Hologic reference, and also to other reports.

We observed an increase in BMD of the spine from the age of 68 in women and 66 in men instead of a steady decrease. This is likely due to increasing degenerative changes, which may cover the decrease of BMD in the vertebra.[21]

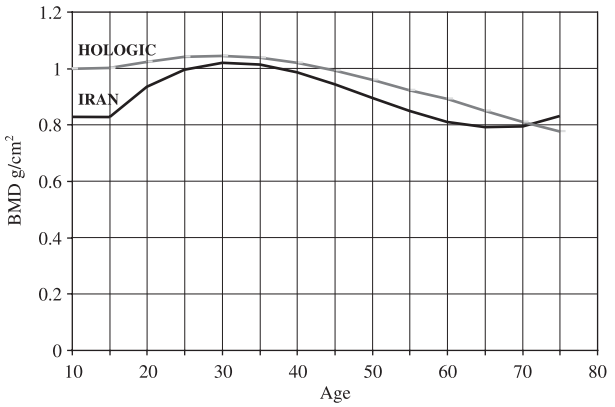


**Figure 1** Comparison of female lumbar spine BMD (total) in Iranian normal population with standard Hologic curve for Caucasians.

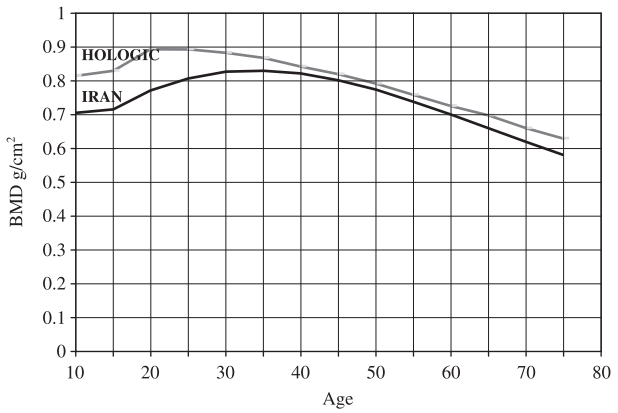


**Figure 2** Comparison of female femoral neck BMD in Iranian normal population with standard Hologic curve for Caucasians.

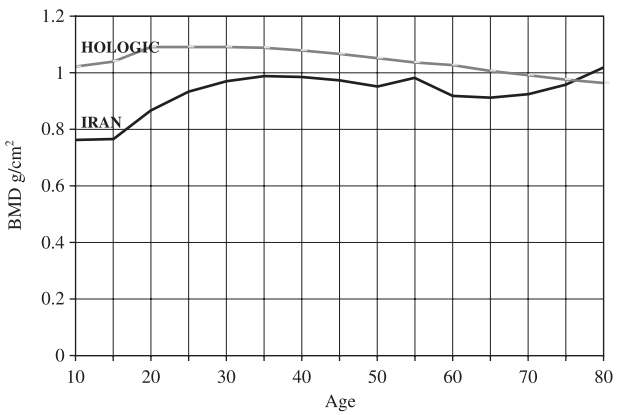


**Figure 3** Comparison of male lumbar spine (total) BMD in Iranian normal population with standard Hologic curve for Caucasians.

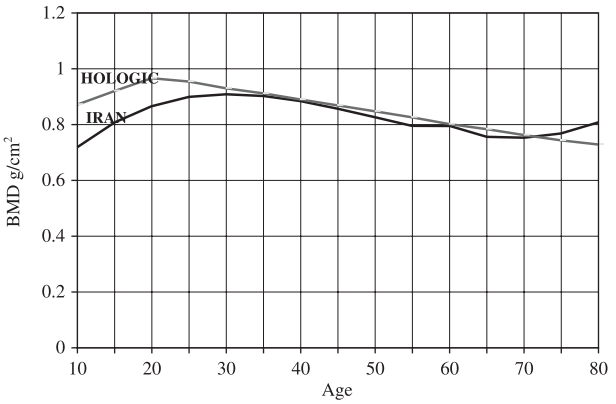


**Figure 4** Comparison of male femoral neck BMD in Iranian normal population with standard Hologic curve for Caucasians.

**Table 6** Comparison of lumbar spine bone mass density in normal Iranian women with the Hologic standard data for Caucasians

| Age (years) | Normal Iranians L1–L4 g/cm² | Hologic standards L1–L4 g/cm² |
|---|---|---|
| 15 | 0.829 | 1.001 |
| 20 | 0.935 | 1.023 |
| 25 | 0.996 | 1.041 |
| 30 | 1.019 | 1.045 |
| 35 | 1.038 | 1.038 |
| 40 | 0.986 | 1.019 |
| 45 | 0.944 | 0.993 |
| 50 | 0.896 | 0.960 |
| 55 | 0.849 | 0.922 |
| 60 | 0.811 | 0.891 |
| 65 | 0.791 | 0.849 |
| 70 | 0.795 | 0.809 |
| 75 | 0.831 | 0.777 |
| 80 | 1.016 | 0.807 |

We searched for osteoporosis in this cohort of a normal population. Osteoporosis was discovered in 8.2% of women. The confidence interval (CI) at 95% was 4–12.8%. In men osteoporosis was discovered in 4.9%. The CI was 1–8.8%. The difference between the two groups was not significant, while higher incidence was expected in women.

## ACKNOWLEDGMENTS

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**Table 7** Comparison of femoral neck bone mass density in normal Iranian women with the Hologic standard data for Caucasians

| Age (years) | Normal Iranians femoral neck g/cm$^2$ | Hologic standards femoral neck g/cm$^2$ |
|---|---|---|
| 15 | 0.715 | 0.830 |
| 20 | 0.772 | 0.893 |
| 25 | 0.808 | 0.893 |
| 30 | 0.827 | 0.883 |
| 35 | 0.831 | 0.867 |
| 40 | 0.822 | 0.842 |
| 45 | 0.802 | 0.819 |
| 50 | 0.774 | 0.791 |
| 55 | 0.732 | 0.760 |
| 60 | 0.700 | 0.727 |
| 65 | 0.660 | 0.698 |
| 70 | 0.620 | 0.661 |
| 75 | 0.582 | 0.630 |

**Table 8** Comparison of lumbar spine bone mass density in normal Iranian men with the Hologic standard data for Caucasians

| Age (years) | Normal Iranians L1–L4 g/cm$^2$ | Hologic standards L1–L4 g/cm$^2$ |
|---|---|---|
| 15 | 0.763 | 1.040 |
| 20 | 0.864 | 1.090 |
| 25 | 0.931 | 1.091 |
| 30 | 0.970 | 1.091 |
| 35 | 0.986 | 1.088 |
| 40 | 0.984 | 1.079 |
| 45 | 0.971 | 1.065 |
| 50 | 0.951 | 1.050 |
| 55 | 0.982 | 1.035 |
| 60 | 0.916 | 1.025 |
| 65 | 0.911 | 1.006 |
| 70 | 0.923 | 0.990 |
| 75 | 0.956 | 0.976 |
| 80 | 1.016 | 0.961 |

**Table 9** Comparison of femoral neck bone mass density in normal Iranian men with the Hologic standard data for Caucasians

| Age (years) | Normal Iranians femoral neck g/cm$^2$ | Hologic standards femoral neck g/cm$^2$ |
|---|---|---|
| 10 | 0.720 | 0.870 |
| 15 | 0.807 | 0.919 |
| 20 | 0.865 | 0.964 |
| 25 | 0.865 | 0.954 |
| 30 | 0.907 | 0.930 |
| 35 | 0.901 | 0.911 |
| 40 | 0.882 | 0.890 |
| 45 | 0.855 | 0.869 |
| 50 | 0.824 | 0.847 |
| 55 | 0.794 | 0.825 |
| 60 | 0.769 | 0.802 |
| 65 | 0.754 | 0.783 |
| 70 | 0.752 | 0.762 |
| 75 | 0.768 | 0.742 |
| 80 | 0.807 | 0.727 |

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