**Supplement and supporting data (SSD)**

Supplementary table 1 – Table of circular RNAs with increased expression correlated to associated hallmarks, involved mechanism of action (target microRNA, target gene, and altered pathways), and code used in this work.

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| **CODE** | **CIRCULAR RNA** | **MECHANISM OF ACTION** | **ASSOCIATED HALLMARK** | **REFERENCE (Ref. code)** |
| C1 | circCAMSAP1 (hsa\_circ\_0001900) | ● Decreases miR-145- 5p ●Increases FLI1 expression | Invasion and metastasis; Proliferative signaling | Chen et al., 2021 (1) |
| C2 | hsa\_circDYNC1H1\_02 3 (hsa\_circ\_0002060) | ● Decreases miR-198 ● Increases ABCB1 expression | Resistance to cell death | Ji et al., 2020 (2) |
| C3 | Circ\_SIPA1L1 (hsa\_circ\_0032462) | ● Decreases miR-379- 5p ● Increases expression of MAP3K9 | Invasion and metastasis; Proliferative signaling | Jun et al., 2020 (3) |
| ● Increases KIF3B | Invasion and metastasis; Proliferative signaling | Gu et al., 2020 (4) |
| ● Decreases miR-411- 5p ● Increases RAB9A expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Xu et al., 2021 (5) |
| C4 | hsa\_circCNIH3\_012 (hsa\_circ\_0002137) | ● Decreases miR-433- 3p ● Increases IGF1R expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Zhang et al., 2022 (6) |
| C5 | circATRNL1 (hsa\_circ\_0092796) | ● Decreases miR-409- 3p ● Increases LDHA expression | Resistance to cell death; Cellular energy dysregulation | Zhanget al., 2021 (7) |
| C6 | circ\_0008932 | ● Decreases miR-145- 5p | Proliferative signaling; Invasion and metastasis; Resistance to cell death | Cao et al., 2021 (8) |
| C7 | circ-CNST (hsa\_circ\_0017311) | ● Decreases miR-578 ● Increases LDHA and PDK1 expression | Invasion and metastasis; Resistance to cell death; Cellular energy dysregulation | Hu et al., 2021 (9) |
| Circular RNA\_CNST (hsa\_circ\_0017311) | ● Decreases miR-421 ● Increases SLC25A3 | Proliferative signaling | Wang et al., 2020 (10) |
| C8 | circPRKAR1B (hsa\_circ\_0008039) | ● Decreases miR-361- 3P ●Increases FZD4 expression ● Stimulates Wnt/B-catenin axis | Invasion and metastasis; Proliferative signaling; Resistance to cell death; Induction of angiogenesis | Feng et al., 2021 (11) |
| C9 | hsa\_circCHD7\_003 (hsa\_Circ\_0084582) | ● Decreases miR-485- 3p ● Increases JAG1 expression | Invasion and metastasis; Proliferative signaling; Induction of angiogenesis | Gao et al., 2021 (12) |
| C10 | hsa\_circADAM22\_002 (Hsa\_circ\_0004674) | ● Decreases miR- 342-3p ● Increases FBN1 expression ● Active via Wnt/β-catenin | Proliferative signaling; Resistance to cell death | Bai et al., 2021 (13) |
| circRNA\_0004674 | ● Decreases miR142-5p ● Increases MCL1 expression | Invasion and metastasis; Signage Proliferative; Resistance to cell death | Ma et al., 2021 (14) |
| C11 | Hsa\_circ\_0032463 | ● Decreases miR330-3p ● Increases PNN expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Qin and Wu, 2021 (15) |
| C12 | Hsa\_circ\_001422 | ● Decreases miR-195-5p ● Increases FGF2 expression ● Active via PI3K/Akt | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Yang et al., 2021 (16) |
| C13 | CircRAB3IP | ● Decreases miR-580- 3p ● Increases TWIST1 expression | Invasion and metastasis; Proliferative signaling | Tang et al., 2021 (17) |
| C14 | Circ\_0056285 | ● Decreases miR-1244 ● Increases TRIM 44 expression | Proliferative signaling; Resistance to cell death; Cellular energy dysregulation | Huo and Dou, 2021 (18) |
| C15 | CircUBAP2 | ● Decreases miR-204- 3p ● Increases HGMA2 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Ma et al., 2021 (19) |
| circUBAP2  | ● Decreases miR 641 ● Increases expression of YAP1 | Invasion and metastasis; Proliferative signaling | Wu et al., 2020 (20) |
| CircUBAP2 | ● Decreases miR-506-3p ● Activates the WNT/β-catenin pathway | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Dong and Qu, 2020 (21) |
| circular RNA UBAP2 | ● Decreases miR-143 | Proliferative signaling; Resistance to cell death | Zhang et al., 2017 (22) |
| C16 | Circ\_0000527 | ● Decreases miR-646 ● Increases ARL2 expression | Invasion and metastasis; Proliferative signaling; Promotion of inflammation | Wu et al., 2021 (23) |
| C17 | hsa\_circ\_0000073 | ● Decreases miR - 1252-5p ● Increases expression of CCNE2 and MDM2 | Invasion and metastasis; Proliferative signaling | Ren et al., 2021 (24) |
| ● Decreases miR 145-5p and miR-151-3p ● IncreaseNRAS expression | Invasion and metastasis; Signage Proliferative; Resistance to cell death | Li et al., 2020 (25) |
| C18 | circPDSS1 | ● Decreases miR-502- 3p and miR-4436a | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Tang et al., 2022 (26) |
| C19 | circFOXP1 | ● Decreases miR-127- 5p ● Increases CDKN2AIP expression | Proliferative signaling; Induction of angiogenesis | Zhang et al., 2021 (27) |
| C20 | CircNRIP1 (hsa\_circ\_0004771) | ● Decreases miR-532- 3p ● Increases AKT3 expression ● Active via PI3K/AKT | Invasion and metastasis; Proliferative signaling | Shi et al., 2021 (28) |
| Circular RNA circNRIP1 | ● Decreases miR-199a ● Increases FOXC2 expression | Invasion and metastasis; Signage Proliferative; Resistance to cell death | Meng et al., 2021 (29) |
| C21 | CircPVT1 (hsa\_circ\_0001821) | ● Decreases miR-423- 5p ● Active via Wnt5a/ROR2 | Invasion and metastasis; Proliferative signaling; Cellular energy dysregulation | Wan et al., 2021 (30) |
| circPVT1 | ● Decreases miR-137 ● Increases TRIAP1 expression | Invasion and metastasis; Signage Proliferative; Resistance to cell death | Li et al., 2021 (31) |
| CircPVT1  | ● Decreases miR-205-5p ● Increases cFLIP expression | Invasion and metastasis; Proliferative signaling | Liu et al., 2020 (32) |
| circPVT1 (hsa\_circ\_0001821) | ● Increases ABCB1 expression | Proliferative signaling; Resistance to cell death | Kun et al., 2018 (33) |
| Circular RNA PVT1 | ●Decreases miR-256b ●Increases FOXC2 expression | Invasion and metastasis | Yan et al., 2020 (34) |
| C22 | circANKIB1 | ● Decreases miR-217 ● Increases PAX3 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Zhu et al., 2021 (35) |
| Circ\_ANKIB1 | ● Increases miR-19b ● Inhibits SOCS3 and activates STAT3 | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Du et al., 2020 (36) |
| C23 | Circular RNA circ\_0081001 | ● Decreases miR-494- 3p ● Increases TGM2 expression | Invasion and metastasis; Resistance to cell death | Wei et al., 2021 (37) |
| hsa\_circ\_0081001  | ● Pathological clinical analysis | Pathological clinical analysis | Kun et al., 2018 (38) |
| C24 | Circ-XPR1 (hsa\_circ\_0005909) | ●Decreases miR-214- 5p ● Increases DDX5 expression | Proliferative signaling | Mao et al., 2021 (39) |
| hsa\_circ\_0005909 | ● Decreases mir-338-3p ● Increases hmga1 expression ● Active via MAPK-ERK and PI3K | Proliferative signaling; Resistance to cell death | Zhang et al., 2021 (40) |
| hsa\_circ\_0005909 | ● Decreases mir-936 ● Increases HMGB1 expression | Invasion and metastasis; Proliferative signaling | Ding et al., 2020 (41) |
| C25 | hsa\_circ\_0007534 | ● Decreases miR- 219a-5p ● Increases SOX5 expression | Invasion and metastasis; Proliferative signaling | Zhang and Li, 2021 (42) |
| ● Activated AKT/GSK-3B | Proliferative signaling; Resistance to cell death | Li and Li, 2018 (43) |
| C26 | Circular RNA 0102049 | ● Decreases miR-520g-3p ● Increases PLK2 axis | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Zhang et al., 2021 (44) |
| circ\_0102049 | ● Decreases miR 1304-5p ● Increases MDM2 mRNA expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Jin et al., 2019 (45) |
| C27 | Circ\_0000885 | ● Decreases miR-1294 ● Increases FGFR1 expression | Invasion and metastasis; Proliferative signaling | Chen et al., 2020 (46) |
| hsa\_circ\_0000885 | ● Pathological clinical analysis | Pathological clinical analysis | Zhu et al., 2019 (47) |
| C28 | CircECE1 | ● Increases c-Myc expression ● Inhibits SPOP degradation and increases TXNIP expression | Invasion and metastasis; Proliferative signaling; Cellular energy dysregulation | Shen et al., 2020 (48) |
| C29 | circ\_ARF3 | ● Decreases miR-1299 ● Increases CDK6 expression | Proliferative signaling | Gao et al., 2020 (49) |
| C30 | Hsa circ 0003732 | ● Decreases miR-545 ● Increases CCNA2 expression | Proliferative signaling | Li et al., 2020 (50) |
| C31 | cir-ITCH | ● Increased cir-ITCH ● Increases miR-7 ● Increases EGFR expression | Invasion and metastasis; Proliferative signaling | Li et al., 2020 (51) |
| C32 | circHIPK3 | ● Decreases miR-637 ● Increases HDAC4 expression | Invasion and metastasis; Proliferative signaling | Wen et al., 2021 (52) |
| ● Decreases miR-637 ● Increases STAT3 expression | Invasion and metastasis; Proliferative signaling | Huang et al., 2020 (53) |
| C33 | circSMARCA5 | ● Interacts with miR-17-3p, miR-432-5p, miR-561-3p, miR-10b-3p, and miR-181c-3p | Invasion and metastasis; Proliferative signaling | Zhang et al., 2020 (54) |
| C34 | hsa\_circ\_0002052 | ● Decreased miR- 382 ● Increased STX6 expression ● Active via Wnt/B-catenin | Invasion and metastasis; Proliferative signaling | Zhang et al., 2020 (55) |
| C35 | CircPRDM2 | ● Decreases miR-760 ● Increases EZH2 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Yuan et al., 2021 (56) |
| C36 | circ\_CDK14 (hsa\_circ\_0001721) | ● Decreases miR- 520a-3p ● Increases GAB1 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Wu et al., 2021 (57) |
| Circrna circ\_0001721 | ● Decreases miR-372-3p ● Increases MAPK7 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death; Cellular energy dysregulation | Gao et al., 2020 (58) |
| circ\_0001721 | ● Decreases miR-569 and miR-599 | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Li et al., 2019 (59) |
| C37 | Hsa\_circ\_0008934 | ● Decreases miR- 145-5p ● Increases E2F3 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Li et al., 2020 (60) |
| C38 | hsa\_circRNA\_0008035 | ● Decreases miR-375 ● Increases NOTCH signaling pathway | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Gong et al., 2020 (61) |
| C39 | has-circ-0001146 | ● Decreases miR-26a-5p | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Wang et al., 2020 (62) |
| C40 | hsa\_circ\_0136666 | ● Decreases miR 593-3p ● Increases ZEB2 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Zhang et al., 2020 (63) |
| C41 | Circular RNA circFAT1(e2) | ● Decreases miR-181b ● Increases HK2 expression | Invasion and metastasis; Proliferative signaling | Gu et al., 2020 (64) |
| C42 | CircUSP34 | ● Decreases miR-16-5p | Invasion and metastasis; Proliferative signaling | Lou et al., 2022 (65) |
| C43 | CircFAM120B(hsa\_circ\_0078767) | ● Decreases miR-1205 ● Increases PTBP1 expression | Invasion and metastasis; Proliferative signaling | Li et al., 2021 (66) |
| C44 | hsa-circ-0016347 | ● Decreases miR-214 ● Increases caspase 1 | Invasion and metastasis; Proliferative signaling | Jin et al., 2017 (67) |
| Circ\_0016347 | ● Decreases miR- 1225-3p ● Increases KCNH1 expression | Invasion and metastasis; Proliferative signaling; Cellular energy dysregulation | Li et al., 2021 (68) |
| C45 | Circ\_0010220 | ● Decreases miR-503-5P ● Increases CDCA4 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Li et al., 2020 (69) |
| Hsa\_circ\_0010220 | ● Decreases miR-198 ● Increases STX 6 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Lu et al., 2021 (70) |
| C46 | CircCRIM1 | ● Decreases miR-432-5p ● Increases HDAC4 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Liu et al., 2020 (71) |
| C47 | circTUBGCP3 | ● Decreases miR-30b ● Increases Vimetin expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Xu et al., 2020 (72) |
| C48 | hsa\_circ\_0003496 | ● Decreases miR-370 ● Increases KLF12 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Xie et al., 2020 (73) |
| C49 | circCCDC66 | ● Decreases miR-338- 3p ● Increases PTBP1 expression | Invasion and metastasis; Proliferative signaling; | Xiang et al., 2020 (74) |
| C50 | circ\_001621 | ● Decreases miR- 578 ● Increases expression of VEGF, MMP9 and CDK4 | Invasion and metastasis; Proliferative signaling; | Ji et al., 2020 (75) |
| C51 | Circ100284 | ● Decreases PTEN and EMP1 | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Liu and Liu, 2020 (76) |
| C52 | Circ0085539 | ● Decreases miR-526b-5p ● Increases PHLDA1 | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Liu et al., 2020 (77) |
| C53 | CircEIF4G2 | ● Decreases miR-218 | Invasion and metastasis; Proliferative signaling | Lin et al., 2020 (78) |
| C54 | circ\_001569  | ● Activates Wnt/β-catenin | Proliferative signaling; Resistance to cell death | Zhang et al., 2018 (79) |
| C55 | Circ-03955 | ● Decreases miR-3662 ● Increases MTDH expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Wang et al., 2020 (80) |
| C56 | Circ\_0086996 | ● Decreases miR-125b-5p | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Luo et al., 2020 (81) |
| C57 | Circular RNA 0060428 | ● Decreases miR-375 ● Increases RPBJ expression | Proliferative signaling; Resistance to cell death | Cao and Liu, 2020 (82) |
| C58 | Circ\_0001658 | ● Decreases miR-382-5p ● Increases YB-1 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Wang et al., 2020 (83) |
| C59 | CircITGA7 | ● Decreases miR-370 ● Increases PIM1 expression | Invasion and metastasis; Proliferative signaling | Fang et al., 2020 (84) |
| C60 | hsa\_circ\_0000282 | ● Decreases miR-192 ● Increases XIAP expression | Proliferative signaling; Resistance to cell death | Li et al., 2020 (85) |
| C61 | circ\_0028171 | ● Increases miR-218-5p ● Decreases IKBKB expression | Invasion and metastasis; Proliferative signaling | Pan et al., 2020 (86) |
| C62 | Circ\_0000285 | ● Decreases miR-409-3p ● Increases IGFBP3 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Long et al., 2020 (87) |
| Hsa\_circ\_0000285  | ● Decreases miRNA 599 ● Increases TGFB2 | Proliferative signaling | Zhang et al., 2020 (88) |
| C63 | Circ-XPO1 | ● Decreases miR-23a-3p, miR-23b-3p, miR-23c, and miR-130a-5p ● Increases XPO1 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death; Evasion of suppressive mechanisms | Jiang et al., 2020 (89) |
| C64 | CircSAMD4A | ● Decreases miR-218-5p ● Increases KLF8 expression | Proliferative signaling; Resistance to cell death | Wei et al., 2020 (90) |
| ● Decreases miR-342-3p ● Increases FZD7 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Xie et al., 2020 (91) |
| C65 | hsa\_circ\_0003074 | ● Pathological clinical analysis | Pathological clinical analysis | Lei and Xiang, 2020 (92) |
| C66 | Circular RNA 0001785 | ● Decreases miR-1200 ● Increases HOXB2 expression ● Active PI3K/Akt/Mtor | Proliferative signaling; Resistance to cell death | Li et al., 2019 (93) |
| C67 | CircMYO10 | ● Decreases miR-370-3p ● Increases RUVBL1 expression ● Active B-catenin/LEF1 complex | Invasion and metastasis; Proliferative signaling; Genome instability and mutation | Chen et al., 2020 (94) |
| C68 | Hsa\_circ\_0051079 | ● Decreases miR- 26a-5p ● Increases TGF-B1 expression | Invasion and metastasis; Proliferative signaling | Zhang et al., 2019 (95) |
| C69 | Circ-0003998 | ● Decreases miR-197-3p ● Increases KLF10 expression | Invasion and metastasis | Wang et al., 2019 (96) |
| C70 | circTADA2A (hsa\_circ\_0043278) | ● Decreases miR-203a-3p ● Increases CREB3 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Wu et al., 2019 (97) |
| C71 | circRNA\_100876 | ● Decreases miR-136 | Proliferative signaling; Resistance to cell death | Jin et al., 2019 (98) |
| C72 | CircRNA LRP6 | ● Inhibits expression of KLF2 and APC | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Zheng et al., 2019 (99) |
| C73 | circMMP9 | ● Decreases miR-1265 ● Increases CHI3L1 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Pan et al., 2019 (100) |
| C74 | circ\_0000502 | ● Decreases miR-1238 | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Qi et al., 2019 (101) |
| C75 | circRNA-0008717 | ● Decreases miR-203 ● Increases Bm1 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Zhou et al., 2018 (102) |
| C76 | CircFAT1 | ● Decreases miR-375 ● Increases Yes-associated protein 1 (YAP1) | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Liu et al., 2018 (103) |
| C77 | Hsa\_circ\_0009910 | ● Decreases miR-449a ● Increases IL6R expression ● Active JAK1/STAT3 | Proliferative signaling; Resistance to cell death | Deng et al., 2018 (104) |
| C78 | hsa\_circ\_0001564 | ● Decreases miR-29c-3p | Proliferative signaling; Resistance to cell death | Song and Li, 2018 (105) |
| C79 | circNASP | ● Decreases miR-1253 ● Increases FOXF1 expression | Invasion and metastasis; Proliferative signaling | Huang et al., 2018 (106) |
| C80 | Circular RNA GLI2 | ● Decreases miR-125-5b | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Li and Song, 2017 (107) |
| C81 | circ-NT5C2 (hsa\_circ\_0092509) | ● Decreases miR-448 | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Liu et al., 2017 (108) |
| C82 | circ-CHI3L1.2 | ● Decreases miR-340-5p ● Increases LPAATB expression | Proliferative signaling; Resistance to cell death | Zhang et al., 2021 (109) |
| C83 | Circ\_ORC2 | ● Increases miR-19a ● Decreases PTEN expression ● Activates the AKT pathway | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Li et al., 2019 (110) |
| C84 | circ\_0000006 | ● Decreases miR-646 ● Increases BDNF expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Amuti et al., 2021 (111) |

Ref. code: the corresponding number of the reference in the reference section. FLI1, Friend leukemia virus integration 1; ABCB1, ATP-binding cassette subfamily B member 1; MAP3K9, Mitogen-activated protein kinase kinase kinase 9; IGF1R, Insulin like growth factor1 receptor; LDHA, Lactate dehydrogenase A; PDK1, Pyruvate dehydrogenase kinase 1; FZD4, Frizzled class receptor 4; JAG1, Jagged canonical notch ligand 1; LEF1, Lymphoid enhancer binding Factor 1; FGF2, Fibroblast growth factor 2; TWIST1, Twist family BHLH transcription factor 1; TRIM44, Tripartite motif containing 44; HGMA2, High mobility group AT-hook 2; ARL2, ADP ribosylation factor like GTPase 2; MCL1, myeloid cell leukemia-1; CCNE2, Cyclin E2; MDM2, Murine doble minute 2 (regulador negativo da P53); CDKN2AIP, Cyclin-dependent kinase inhibitor 2a-interacting protein; AKT3, Serine/Threonine Kinase 3; PI3K, Phosphoinositide 3-kinase; AKT, Protein Kinase B; WNT5A, Wnt family member 5ª; ROR2, Receptor tyrosine kinase like orphan receptor 2; RAB9A, Ras-related protein Rab-9ª; PAX3, Paired box 3; TGM2, Transglutaminase 2; DDX5, DEAD box protein 5; SOX5, SRY-Box Transcription Factor 5; HMGA1, High mobility group AT-Hook; MAPK, Mitogen‑activated protein kinase; ERK, Extracellular signal-regulated kinase; PLK2, Polo like kinase 2; SOCS3, Suppressor Of Cytokine Signaling 3; STAT3, Signal transducer and activator Of transcription 3; FGFR1, Fibroblast growth factor receptor 1; TXNIP, Thioredoxin interacting protein; CDK6, Cyclin dependent kinase 6; CCNA2, Cyclin A2; EGFR, epidermal growth factor receptor; SLC25A3, Solute carrier family 25 member 3; HDAC4, Histone deacetylase 4; TRIAP1, TP53 Regulated Inhibitor Of Apoptosis 1; STX6, Syntaxin 6; EZH2, Enhancer of zeste 2 polycomb repressive complex 2 subunit; GAB1, GRB2-associated binder 1; E2F3, E2F Transcription Factor 3; ZEB2, Zinc finger E-Box binding homeobox 2; HK2, Hexokinase 2; PTBP1, Polypyrimidine tract binding protein; KCNH1, Potassium voltage-gated channel subfamily H member 1; KLF, Krueppel-like factor; KLF12, KLF Transcription Factor 12; MAPK7, Mitogen-activated protein kinase 7; VEGF, Vascular endothelial growth fator; MMP-9, Matrix metalloproteinase 9; CDK4, Cyclin dependent kinase 4; c-FLIP, Cellular FLICE (FADD-like IL-1β-converting enzyme) inhibitory protein; HMGB1, High mobility group box 1; PTEN, phosphatase and tensin homologue; EMP1, Epithelial membrane protein 1; KIF3B, Kinesin family member 3B; YAP1, Yes-associated protein 1; CDCA4, Cell Division Cycle Associated 4; PHLDA, Pleckstrin Homology Like Domain Family A Member 1; MTDH, Metadherin; YB-1, Y-box binding protein 1; PIM1, Proto-Oncogene, Serine/Threonine Kinase; XIAP, X-Linked Inhibitor Of Apoptosis; IKBKB, Inhibitor of nuclear factor kappa b kinase subunit beta; IGFBP3, Insulin-like growth factor-binding protein 3; XPO1, Exportin 1; KLF8, Kruppel Like Factor 8; TGFB2, transforming growth factor beta 2; FZD7, Frizzled class receptor 7; HOXB2, Homeobox B2; RUVBL1, RuvB Like AAA ATPase 1; KLF10, KLF Transcription factor 10; KLF2, KLF Transcription fator 2; APC, APC Regulator of wnt signaling pathway; CHI3L1, Chitinase 3 Like 1; GSK3B, Glycogen synthase kinase-3β; BM1, Proto-oncogene, polycomb ring finger; IL6R, Interleukin 6 Receptor; FOXF1, Forkhead Box F1; FOXC2, Forkhead Box C2; LPAATB, Lysophosphatidic acid acyltransferase b; BDNF, Brain Derived Neurotrophic Factor; PVT1, plasmacytoma variant translocation 1.

**References Supplementary table 1**

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Supplementary table 2 – Table of circular RNAs with decreased expression correlated to associated hallmarks, involved mechanism of action (target microRNA, target gene, and altered pathways), and code used in this work.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **CODE** | **CIRCULAR RNA** | **MECHANISM OF ACTION** | **ASSOCIATED HALLMARK** | **REFERENCE (Ref. code)** |
| C84 | hsa\_circ\_SLC35E2B\_001 (hsa\_circ\_0000006) | ● Increases miR 361-3p ● Decreases LRIG1 expression | Invasion and metastasis; Proliferative signaling | Gao et al., 2021 (1) |
| C85 | Circular RNA circ\_0046264 | ● Increases miR-940 ● Decreases SFRP1 expression | Invasion and metastasis; Proliferative signaling | Du et al., 2021 (2) |
| C86 | circVRK1 | ● Increases miR-337-3p ● Decreases ZNF652 expression | Invasion and metastasis; Proliferative signaling | Cheng et al., 2021 (3) |
| C87 | Circular RNA MTO1 | ● Pathological clinical analysis | Pathological clinical analysis | Shi et al., 2021 (4) |
| ● Increases miR-630 ● Decreases KLF6 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Liu et al., 2021 (5) |
| C88 | hsa\_circ\_0000658 | ● Increases miR-1227 ● Decreases IRF2 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Jiang and Chen, 2021 (6) |
| C89 | hsa\_circ\_0001649 | ● Increases miR-338-5p, miR-647 and miR-942 ● Active STAT3 signaling pathway | Proliferative signaling; Resistance to cell death | Sun and Zhu, 2020 (7) |
| C90 | Circ\_WWC3 | ● Increases miR-421 ● Decreases PDE7B | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Liu et al., 2021 (8) |
| C91 | Hsa\_circ\_0088212 | ● Increases miR-520h ●Decreases APOA1 expression | Proliferative signaling; Resistance to cell death | Liu et al., 2021 (9) |
| C92 | circ\_0001105 | ● Increases miR-766 ● Decreases YTHDF2 expression | Invasion and metastasis; Proliferative signaling; Genome instability and mutation | Yang et al., 2020 (10) |
| C93 | Hsa\_circ\_0008792 | ● Increases miR-711 ● Decreases ZFP1 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Chen et al., 2020 (11) |
| C94 | hsa\_circ0021347 | ● B7-H3 decreases hsa\_circ0021347 | Not cited | Wang et al., 2019 (12) |
| C31 | CircITCH | ● Increases miR-524 ● Decreases RASSF6 expression | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Zhou et al., 2021 (13) |
| C32 | circ\_HIPK3 | ● Not cited | Invasion and metastasis; Proliferative signaling | Xiao-long et al., 2018 (14) |
| C34 | hsa\_circ\_0002052 | ● Increases miR-1205 ● Decreases APC2 expression ● Active Wnt/B-catenin | Invasion and metastasis; Proliferative signaling; Resistance to cell death | Wu et al., 2018 (15) |

Ref. code: the corresponding number of the reference in the reference section. STAT3, Signal transducer and activator Of transcription 3; LRIG1, Immunoglobulin-like domains protein 1; RASSF6, Ras association domain family member 6; SFRP1, Secreted Frizzled Related Protein 1; ZNF652, Zinc Finger Protein 652; IRF2, Interferon regulatory factor 2; KLF6, KLF Transcription fator 6; PDE7B, Phosphodiesterase 7B; APOA 1, Apolipoprotein A1; YTHDF2, YTH N6-methyladenosine rna binding protein 2; ZFP1, ZFP1 Zinc Finger Protein; APC2, APC Regulator Of WNT Signaling Pathway 2.

**References Supplementary table 2**

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**Supplementary materials and methods**

*Research strategy in databases.*

PUBMED

#1 ((((((((((((((((RNA, Circular) OR (circRNAs)) OR (Closed Circular RNA)) OR (Circular RNA, Closed)) OR (RNA, Closed Circular)) OR (Circular RNA)) OR (Circular RNAs)) OR (RNAs, Circular)) OR (circRNA)) OR (Circular Intronic RNA)) OR (Intronic RNA, Circular)) OR (RNA, Circular Intronic)) OR (ciRNA)) OR (exonic circRNA)) OR (ecircRNA)) OR (EIciRNA)) OR (exon-intron circRNA)

AND

#2 (((((((((Osteosarcoma) OR (Osteosarcomas)) OR (Osteosarcoma Tumor)) OR (Osteosarcoma Tumors)) OR (Tumor, Osteosarcoma)) OR (Tumors, Osteosarcoma)) OR (Sarcoma, Osteogenic)) OR (Osteogenic Sarcomas)) OR (Sarcomas, Osteogenic)) OR (Osteogenic Sarcoma)

SCOPUS

((circular ribonucleic acid) OR (circular RNA) OR (RNA, circular) OR (circRNA) OR (Closed Circular RNA) OR (RNA, Closed Circular) OR (Circular Intronic RNA) OR (Intronic RNA, CircularOR (RNA, Circular Intronic) OR (ciRNA) OR (exonic circRNA) OR (ecircRNA) OR (EIciRNA) OR (exon-intron circRNA))

((osteosarcoma) OR (bone AND sarcoma) OR (intracortical AND sarcoma) OR (osteogenic AND sarcoma) OR (osteoide AND sarcoma) OR (osteolytic AND sarcoma) OR (osteosarcoma, AND uxtacortical) OR (primary AND osteogenic AND sarcoma) OR (sarcoma, AND bone) OR (sarcoma, AND osteogenic))

EMBASE

#1 'circular ribonucleic acid'/exp OR (circular RNA) OR (RNA, circular) OR (CircRNA) OR (Closed Circular RNA) OR (RNA, Closed Circular) OR (Circular Intronic RNA) OR (Intronic RNA, Circular) OR (RNA, Circular Intronic) OR (ciRNA) OR (exonic circRNA) OR (ecircRNA) OR (EIciRNA) OR (exon-intron circRNA)

#2 'osteosarcoma'/exp OR (Bone Sarcoma) OR (Intracortical Sarcoma) OR (Osteogenic Sarcoma) OR (Osteoid Sarcoma) Or (Osteolytic Sarcoma) OR (Osteosarcoma, Juxtacortical) OR (Primary Osteogenic Sarcoma) OR (Sarcoma, Bone) OR (Sarcoma, osteogenic)

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#1 'osteosarcoma'/exp OR 'osteosarcoma' OR (('bone'/exp OR bone) AND ('sarcoma'/exp OR sarcoma)) OR (intracortical AND ('sarcoma'/exp OR sarcoma)) OR (osteogenic AND ('sarcoma'/exp OR sarcoma)) OR (('osteoid'/exp OR osteoid) AND ('sarcoma'/exp OR sarcoma)) OR (osteolytic AND ('sarcoma'/exp OR sarcoma)) OR (('osteosarcoma,'/exp OR osteosarcoma,) AND juxtacortical) OR (primary AND osteogenic AND ('sarcoma'/exp OR sarcoma)) OR (('sarcoma,'/exp OR sarcoma,) AND ('bone'/exp OR bone)) OR (('sarcoma,'/exp OR sarcoma,) AND osteogenic)

#2 'circular ribonucleic acid'/exp OR 'circular ribonucleic acid' OR (circular AND ('rna'/exp OR rna)) OR (('rna,'/exp OR rna,) AND circular) OR 'circrna'/exp OR circrna OR (closed AND circular AND ('rna'/exp OR rna)) OR (('rna,'/exp OR rna,) AND closed AND circular) OR (circular AND intronic AND ('rna'/exp OR rna)) OR (intronic AND ('rna,'/exp OR rna,) AND circular) OR (('rna,'/exp OR rna,) AND circular AND intronic) OR cirna OR (exonic AND ('circrna'/exp OR circrna)) OR ecircrna OR eicirna OR ('exon intron' AND ('circrna'/exp OR circrna))

WEB OF SCIENCE

((circular ribonucleic acid) OR (circular RNA) OR (RNA, circular) OR (circRNA) OR (Closed Circular RNA) OR (RNA, Closed Circular) OR (Circular Intronic RNA) OR (Intronic RNA, CircularOR (RNA, Circular Intronic) OR (ciRNA) OR (exonic circRNA) OR (ecircRNA) OR (EIciRNA) OR (exon-intron circRNA))

((osteosarcoma) OR (bone AND sarcoma) OR (intracortical AND sarcoma) OR (osteogenic AND sarcoma) OR (osteoide AND sarcoma) OR (osteolytic AND sarcoma) OR (osteosarcoma, AND juxtacortical) OR (primary AND osteogenic AND sarcoma) OR (sarcoma, AND bone) OR (sarcoma, AND osteogenic))